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PSEUDOSCIENCE AND ANTISCIENCE IN AN AGE OF SCIENCE*

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This paper is about an unpleasant subject, pseudoscience and antiscience. In this age of enlightenment and of a far-reaching public press, it seems incredible that these are so widespread. Possibly it is as we might expect from the perversity of human prejudice and the lag of the mind of the multitude behind the conceptions of the scientists.

Pseudoscience and antiscience are not so distinct as they might seem. The old pseudoscience astrology and the strong antiscientific, antievolution movement which culminated in the antievolution law of Tennessee in 1925 and two other states shortly thereafter, will be cited.

Astrology is still rampant. Daily astrological horoscopes are found in our newspapers and in the large magazine stores there are many astrological magazines. They do not appear antiastronomical and may seem to be a harmless absurdity. But try to show this absuridity to a confirmed believer and you will recognize the antiscience which animates him.

In the antievolution movement there developed a strong pseudoscience. I refer not to the view of a large number of people, who, unaware of the nature and evolution of man and the universe, more or less feel they do not care about evolution or feel that evolution is irreligious. Instead, I refer to a relatively small number who write plausible tracts and books to be read by the aforementioned large group. For the most part these writers understand only a few of the facts. They are confused by some statements about data and unwittingly misuse them. The result is often considerable misrepresentation of the scientific evidence and concepts.

Among the best known of the pseudoscientific developments in this field was the so-called upside down geology of George McCready Price, geological authority of the Seventh Day Adventists. In his books (e.g., Price, 1926) he made much ado about the small areas of the west where thrust faulting had reversed certain strata, making them upside down so to speak. Despite the fact that geologists know the true time sequence of these strata over the continent, the reversed local position was all that Price needed to convince his readers that the fossils showed the evolutionary sequence wrong and that hence evolution was disproved.

The last antievolution book I read and closely analyzed (in the summer of 1947) bears the title "*After Its Kind,*" *The First and Last Word about Evolution* by Byron Nelson, Th.M. (1927).

You may be able to visualize the nature of the book by an example; I use the

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first example, the frontispiece with explanation. Since it is concise, I shall quote it in full.

FIG. I. Fossil cockroach from the so-called Carboniferous, supposed to have been deposited half a billion years ago. Cockroaches identical with this fossil form are living today. Concerning other insects it has been said "Certain Fossil insects well preserved in amber from geological periods which are reckoned by millions of years, differ in no perceptible way from individuals of the same species today." Professor D. F. Jones, Yale University (Genetics, p. 26.) "The only difference between a fossil and a recent animal is that one has been dead longer than the other" . . . Huxley (Biology and its Makers, by Locy, p. 335.) Fossil from Smithsonian Institute.

This is the quotation in connection with a picture of a fossil cockroach. The included quotations from Jones (1925) and from Locy (1908), which latter includes part of a statement of Huxley, are much out of context.

My answer will not be so concise. The half billion years is an exaggeration, to make his readers feel that the figure is most outlandish. From beginning of the Carboniferous or Mississippian period is about half that long, 250 million years. The first winged insects, Paleodictyoptera, occurred a little later, in early Pennsylvanian period. In the same period appeared Protoblattoidea or first primitive cockroaches, as well as others. Cockroaches comprise the family showing least evolution in morphological characters. It would not have served his purpose to refer to any of the larger and higher orders of insects with their relatively rapid evolution in many branches. There was much diverging evolution in insects in the Permian period and also in the 135 million years of the Mesozoic Era. By the beginning of the Cenozoic Era of 60 million years, all modern orders and most of their families were existing. Only newer genera and species continued appearing (Zittel, 1927).

Amber insects date from Oligocene epoch, about 40 million years ago, about one-third way up from beginning of the Cenozoic, and is at least five-sixths of the way along in time from the primitive first-winged insects. They are much like the insects of today, and to the layman they would look alike. For a concise statement on amber ants I quote from *Prehistoric Life* by Raymond (1939) who says, "Only 44% of the genera of amber ants seem to be extinct: eight of the species are practically indistinguishable from forms now living." Nelson would not like to know about the extinct genera. He stresses the few indistinguishable from living ones.

He read of the Huxley statement in Locy who, in a 19 line paragraph, makes very clear what Huxley meant. To offset the idea that fossils were merely dead, hard things of use as time markers, he stressed that paleontology was the study of organisms merely dead longer than the kinds with which people are familiar. Locy's last sentence reads, "The Statement of Huxley, that the only difference between a fossil and a recent animal is that one has been dead longer than the other, represents the spirit in which the study is being carried forward."

By cutting off the last line Nelson makes his readers feel that fossils are not very old and are of about the same age. In many places in the book he belabors this trying to convince his readers that the one Noachian deluge explains all.

Every page of the book contains errors. I must, before leaving it, point out that the first word about evolution in his intriguing title is Genesis, and the last word about evolution is Mendelian heredity, which he misunderstands as being contradictory to evolution and which he therefore makes much of in the last parts of his book.

Evolution is, of course, a fundamental principle in biological science, attested to by a tremendous, almost illimitable amount of evidence in nature. It is interesting and pertinent to see how, even long before as much was known of it as is known today, evolution had made a convincing impact upon the thought of man. There was relatively fast acceptance of the ideas of Darwin in his own time.

After his return from the Beagle voyage in 1836, Darwin dedicated himself to his work until his death. In 1859 appeared *The Origin of Species*. Quite a few leading scientists fully accepted it, but mainly there was strong criticism and protest. We recall the crowded meeting at which Bishop Wilberforce attacked it and Huxley defended it. But the attitude changed quickly. Even in 1871, when *The Descent of Man* appeared, applying the conception to man himself, the storm of protest was shorter-lived.

Before his death, honors came to Darwin. Cambridge University gave him a doctorate. The chancellor proclaimed, "You who have so learnedly illustrated the laws of nature are hereby declared our doctor of laws" (Moore, 1955). Darwin died in 1882 and was buried in Westminster Abbey. Scientists and statesmen of wide renown were there to honor him. Canon Farrar was among the pall bearers. The Church of England had accepted him and honored him. But it is ironical that even today so many people do not know this.

Most of the opposition to evolution has been due to the idea in the minds of people that evolution is irreligious. Science and religion are two different fields in many ways, and partly in the same ways as science and the humanities are two different fields. The methods of science study; the investigations in evolutionary biology, such as paleontology, embryology, and genetics, obviously differ from religious studies.

We have often read about the war between religion and science. If viewed in an objective way, it has been rather the intolerance of man of new ideas, the opposition of a fixed medieval theology to a growing and changing science, the contention of dogmatists that strict literal interpretation of early biblical writings be accepted just as the prescientific age people envisioned them, regardless of how childish a cosmogony that implied. And pathetically the fundamentalists still try to preserve this intolerance and medievalism. They do religion a disservice.

We know that at one time theologians and others regarded the idea of the rotundity of the earth and its movement around the sun as major heresies. Gradually more modern ideas of the universe became acceptable. Now the inconceivably enormous extent of the universe is accepted and even the idea of its evolution is accepted, or at least tolerated. Organic evolution is accepted not only by the modernistic groups but by numbers of people of education—the thinkers, scientists and leaders of many religious denominations. But we should not overlook the fact that the fundamentalists who still oppose evolution comprise groups of very large membership.

Dean Shailer Mathews (1922) aptly and concisely stated, "It is only those who are ignorant both of the origin and nature of the Bible and the facts of our universe who are terrified lest science should make them lose their faith."

In his review of John Burrough's book *Accepting the Universe*, Fisher (1920) selected a significant statement from the chapter, "The Faith of a Naturalist"; I quote, "Were not Darwin, Huxley, Tyndall and Lyell, and all other seekers and verifiers of natural truth among the most truly religious men? Any of these men would have gone to hell for the truth—not the truth of creeds and rituals, but the truth as it exists in the councils of the Eternal, and as it is written in the laws of matter and of life."

We are reminded by Reverend John O'Brien (1930) of the strong support for evolution of that distinguished geologist and paleontologist and likewise distinguished scholar of the Catholic Church, Canon de Dorlodot. As the official representative of the University of Louvain to the Darwin centenary at Cambridge in 1909, Dr. Dorlodot gave a remarkable tribute, attributing to Newton, and to Darwin for the organic realm, the correct interpretation of the universe.

The history of man's fight against diseases that plague his body is replete with instances of brilliant ideas and effective experimentation. But it is also replete with persistence of primitive conceptions and of obstruction to medical advances.

There is the unfortunate opposition of befuddled people who both fear the new medical advances and cling with credulity to outmoded practices. There is the cupidity of quacks.

Animal experimentation has yielded infinitely much to medical progress. Obviously experiments with rats and mice, guinea pigs, cats, dogs, monkeys and others, have allowed much exploratory work, which when perfected could be done on human beings. But it could not have been initiated on humans. There can be no reasonable objection to animal experimentation. Religion does not oppose it. It has in fact been stated that man is in duty bound to so experiment, as justifiably as he uses animals for other purposes.

But there developed opposition on the part of people who are proud of the label antivivisectionists, people who bear more humaneness to the dog than they do to humanity. They make two broad, amazing claims that the work is cruel and that it has no value. To be objectively fair is not within the makeup of these opponents. When presented with a long list of cases of medical progress due to animal experimentation, they ignore it. Vivisection has a foreboding sound. Meaning "live cutting," it is pictured as cutting up live animals, so that it can be claimed that surgeons are sadistic torturers. If they called it animal surgery, they would lose their chief incentive for attack. They could not admit that the experimental surgeon carries out the operation with anaesthesia and the same care as on humans, so that the dog may live and the operation be proved a success, a necessary preliminary to its use on humans.

Animal experimentation is of much greater scope than just surgery, and many more animals are used in testing drugs, inoculations, physiological experiments, and others.

The awakening of medical scientists to the need of counter-acting the anti-vivisectionists (dating from about 1920), by explanation of the truth of the nature of the work, has gradually improved the situation. Chief in this educational campaign is the National Society for Medical Research, Chicago. Publications and reprints of this society, and publications of the A.M.A. and others, have helped disseminate information to the public.

The antivivisectionists lost their chief purveyor of lurid propaganda at the death of newspaper publisher William Randolph Hearst. Gradually they have had to retreat but it is sure they always retrench.

Scarcely a year ago a bill was passed by the Ohio Legislature giving medical scientists the use of animals from dog pounds, animals which would otherwise be destroyed in the pounds. At the consideration of this bill, antivivisectionists joined forces with many who claimed they were not against animal experimentation, but merely opposed to the bill for various reasons. Devious reasoning went with some of this opposition, for example that the passage of the bill was a dire threat to humane societies. None of the opposition would admit the important point that thousands of animals collected by the animal pounds are destroyed and have hence no usefulness, whereas the use of these or some in medical experiments would yield results and also lessen the cost of the necessary animals to the medical institutions.

I know about the emotionalism of the antivivisectionists. I wrote an article entitled, "Anti-vivisection versus your Health" (Kraatz, 1949). Following that, I received many letters emotionally upbraiding me.

Another incident might be recalled. Someone found a spider spinning under the glass of a clock dial. He took it to a newspaper where someone on the staff foisted it upon me. A big story was made of it, and I was supposed to be doing something scientific with it. I hastily returned it to the newspaper. In the U. S. and abroad newspapers carried the tale of the spider's spinning against the relentless movement of the hands of the clock. I was the recipient of a sheaf of letters all deploring my cruelty to the poor spider. It was an experience with the most misguided, emotional, sentimental fringe of *Homo sapiens*.

For enlightenment, whenever medical progress due to medical experimentation is announced in newspapers, it should be made clear just how the animal work was necessary to yield the results. That is occasionally done nowadays. Had it been done invariably and from early times, much good might have been accomplished.

Very effective was the account used in the magazine *Life* (Anon., 1949). It included a full page picture of a boy with his arm around a dog, a dog used in the original experiments at Johns Hopkins Hospital by Dr. Blalock, who first perfected the so-called blue-baby operation. The boy's life had been saved by such operation. The dog was in good health and enjoying the finest old age a dog can enjoy. Another telling event was the ceremony of the bestowal of the first annual Whipple prize for "outstanding service to humanity" upon two dogs which had been used for blood plasma experimentation so valuable in saving lives of World War II soldiers.

We also can use emotional appeal, but this is appeal not based on sentimentalism, but on behalf of freedom for medical research on animals.

People opposed to vaccination are a declining group. The long proven efficacy of smallbox vaccination and diphtheria inoculation is recognized by the public. I remember well years ago outbursts in public print about "shooting dirty pus and poison into innocent children's blood."

When we speak of Christian Science, it is to be emphasized that we have no quarrel with it as a religion. We have no thought of forcing medication upon people who believe their religious views are against it. It is traditionally American to respect views regardless how unfortunate their results. But we look with pity upon the unfortunate child whose life is sacrificed because his misguided parents will not permit a blood transfusion.

My reason for reference to Christian Science was the New York State case where, with respect to compulsory health and hygiene teaching in the public schools, Christian Scientists in 1950 secured passage of a bill or amendment exempting their children from attendance at health teaching periods.

One of the Christian Scientists in a letter in Science (Metcalf, 1951) waxed rhetorical about health teaching as a form of statism; he said that scientific theories were not necessarily true, and that it was bigotry to make children take health teaching. The answer (Kraatz, 1951) maintained that health teaching is valuable to the children, it is not indoctrinating a theory, and that bigotry resided rather in the elders who wanted to prevent their children learning about health, hygiene and some simple medical facts.

The chiropractic art or profession may be examined. Some chiropractors advertise such features as x-ray therapy, drugless therapy, electrotherapy, "massotherapy," "ultrasonic therapy," and "plasmatic therapy." We are told that chiropractic deals with subluxated vertebrae which must be correctly adjusted by hand, giving relief to impinged nerves, thereby curing everything that can ail you in the area supplied by the nerves.

There were published diagrams of longitudinal section of head and trunk, showing vertebrae and emergence of spinal nerves, with names of body parts and arms and legs, in plausible sequence up and down the back. In the head was the brain outline, but no cranial nerves. Sense organs and other cranial nerve innervated parts were taken care by names such as eye, ear, nose, etc., placed in the cervical vertebrae region! I have put this in the past tense because such diagrams which for years occurred in chiropractors' advertisements no longer appear in our newspapers. I hope this signifies real anatomical enlightenment.

Medical quackery has cut a wide swath in this country. One of its main forms has been the manufacture of patent medicines, in which the chief motive was profit to the manufacturer. Concoctions of colorful liquids, with low-priced ingredients, but nice medical taste, were sold for high prices. Labels on the bottles

enticingly told that they were a cure for this and that. Unquestionably the worst feature of this business was the credulity of the users, who were lulled into belief that they were curing themselves and who refrained from seeing a physician for diagnosis. Some of the medicine imbibers gave testimonials, often solicited, which the manufacturers used effectively.

The pure food and drug laws did much to eliminate one fault of the labeling. No longer do the bottle labels claim cure for so-and-so. They merely say in fine print that they are a remedy or advised for the same so-and-so.

Other forms of quackery are the devices used, some scarcely above the level of charms or amulets, but some more elaborate looking machines. These machines supposedly effect remarkable cures. Much improvement in this deplorable situation has been accomplished by the American Medical Association in its campaign to eradicate this sort of humbug. It is, however, a continuing battle.

In the A.M.A. popular journal *Today's Health*, one important case is explained by George P. Larrick, U. S. Commissioner of Foods and Drugs in two signed articles (Larrick, July 1956 and Feb. 1957). "Public Warning" is given about a cancer medicine dispenser who it is related was twice convicted in courts of using what they unequivocably term "worthless treatment."

Most amazing is that (and not referring to thousands of people who swallowed this medicine) a group designating themselves as a "Better Health Bureau," in Cleveland, approve of this cancer medicine dispenser. A representative gave a talk in Akron lauding this "treatment."

Also amazing is that under the same sponsorship of this Akron talk there was another talk by an antifluoridationist. This seems like the supreme contradiction, approving "cancer medicine," and at the same time condemning fluoridation as medication of water.

This speaker, an authority of the antifluoridationists, wrote a book he entitled *The Drama of Fluorine, Arch Enemy of Mankind.* I have so far not read this magnum opus. But its author, Leo Spira, wrote a series of papers which are declared scientifically invalid by Dr. Gerald Cox in his chapter in the A.A.A.S. symposium, *Fluoridation as a Public Health Measure* (Cox, 1954). Also a "Fluoridation Reading Room" was arranged, presenting exclusively antifluoridation reading matter.

The underlying deeper common denominator may be an obsession of opposition to all scientific medicine as if it were an antipersonal, oppressive enemy.

Who are the antifluoridationists? They include antimedical groups, Christian Scientists, chiropractors, and some others. They include a very few older physicians and dentists, whose knowledge of biochemistry terminated with their textbook written circa 1920, which could mention fluorides only in connection with mottled enamel. Their idea is about as outmoded as the old dictionary defination of uranium, described as an element "having no important uses." They include persons who insist that adding fluorides to water is compulsory medication, interference with individual rights, and a step to statism, and even that it is a subtle effort of the Soviets to poison and weaken people! They carry on their campaign cleverly enough to influence many people who are not getting scientific facts. They halt at nothing; for example, they have made vicious criticism of the United States Public Health Service.

This phenomenon was investigated in Northampton, Massachusetts and presented in the *Scientific American* under the title "A Study of the Anti-scientific Attitude" (Mausner, 1955). As a subtitle there was this summary: "It has been clearly demonstrated that fluoridation tends to prevent tooth decay and does no harm. Then why are many people violently against it? How the question was investigated in Northampton, Massachusetts." The authors cited the main opposition argument as having three themes: "(1) fluoridation is an experiment which has not proved its value and may hold unknown dangers; (2) fluorides are

poisons; (3) treatment by public agencies of the water that everyone must drink is a step in the direction of socialized medicine and an invasion of individual rights."

The ten-year Kingston-Newburgh study in New York and studies in other places proved the value of fluoridation. People have lived all their lives in areas where water contains even several times as much fluorides as the advised optimum of 1 ppm without suffering more diseases or shortened lives as compared with people living elsewhere. This is sufficient proof of the absurdity of the claim by frightened people who, after fluorides were introduced into their water, said they suffered some serious illnesses. In fact in some places these antifluoridationists suffered these alleged dire illnesses at once when fluoridation supposedly had started, but when unknown to them there was a delay in actually starting the machinery. There is a much greater range of tolerance to fluorides in water in such concentrations used, than in the use of many other things, including many medicines and freely-used sleeping remedies.

Some antifluoridationists formed the so-called Ohio Pure Water Association. Do they mean H_2O alone? There is no such thing as pure water in nature. All natural waters include traces of many substances in solution. There are varying tiny amounts of fluorides in nearly all natural waters. The Ohio Department of Public Health publishes a list (Anon., 1954), giving fluoride content of natural waters used by 140 cities and 473 villages. Akron happens to have 0.2 ppm in its water. And at the time of the report, five Ohio cities were adding fluorides to their municipal water. Since then Cleveland has added them. Also 4 cities and 97 villages have in their water naturally about 1 ppm or over. I wonder what the opponents of bringing our Akron water from 0.2 ppm up to 1ppm of fluorides would do if they lived in Delphos which has 1.4 ppm, or in Deshler, which has 1.6. If they did not know about it they would be perfectly healthy and happy in Delphos, or Deshler.

These antis are clever. If confronted with instances of larger natural concentrations, they have a ready argument; they try to imagine a difference between natural and artificial fluorides and claim the artificial are much more poisonous, hundreds of times as much as natural fluorides. Their claim is wrong, as every competent chemist knows. The fluorides introduced are, of course, natural fluorides, i.e. coming ultimately from nature. One of the compounds may be used rather than another for practical reasons.

As reported recently in Science (Anon., 1957) the World Health Organization made a strong endorsement of fluoridation of water after a study in seventeen countries. In this study it was shown that in the U. S. alone 32 million people in 1500 communities use fluoridated water.

In closing this section of my paper I use a statement attributed to William Osler; "In all matters relating to disease credulity remains a permanent fact uninfluenced by civilization or education." To this I add, antiscientists of fixed obsessions and determination exploit this credulity.

I turn to a different and possibly trivial instance of antiscientific attitude.

Two people showed me a specimen of *Pectinatella magnifica*, of class Bryozoa, a rounded, gelatinous, massive animal colony attached to submerged branches found in lakes. They had somehow heard of ambergris, a morbid intestinal secretion of sperm whales valuable in the perfume industry. By a process of wishful thinking they had arrived at the hope and expectation that they had something like ambergris or something just as valuable. Despite my lengthy explanation, they left dissatisfied.

This is unscientific thinking, coupled with distrust of scientists. There are many people who, in submitting for testing something which can be checked with an instrument showing results, especially if expressed by a color, or light, or click or a buzz, will be impressed, even though they understand nothing, but who will

not be impressed by the explanation of a scientist sitting across the table from them, regardless of how clear or valid the explanation is.

In the parade of antiscientific manifestation none seems to have had so much sudden attention as the battery additive case. A battery additive was tested by the Bureau of Standards and declared worthless. But the Senate Small Business Committee took up the cudgels for the manufacturer. The Secretary of Commerce put his foot into it, issuing a notorious statement: "I think that the National Bureau of Standards has not been sufficiently objective because they discount entirely the play of the market place." As the editor of Science said (DuShane, 1956), "A curious view of objectivity!" The Secretary's dismissal of the director of the Bureau of Standards met with such repercussion that the director was reinstated. A committee of the National Academy of Science, appointed to check the tests, confirmed the Bureau's findings. This might have been a victory for science and the scientific method.

But charges of false advertisement of the battery additive were dropped by the Federal Trade Commission. Consumer testimony was valued as much as scientific testing. Now defense lawyers for a worthless product will be more bold to plead their case. Testimonials by untrained laymen can be worthless.

From what I have shown of pseudoscience and antiscience, can we see some common pattern of fault? Usually credulity looms large, bias is common, prejudice is extensive. The result is intolerance, especially of things which seem to outmode cherished, ancient beliefs. And when emotionalism begets opposition to a scientific procedure, the results are often lamentable.

I quote from Chester H. Rowell s "The Cancer of Ignorance, the Spread of Anti-Science in an American Commonwealth" (Rowell, 1925).

> Anti-Science is something more than mere unscientific thinking or lack of scientific information. It is an active emotional hostility to science, to its conclusions, and especially to its process of reaching them. It is repudiation of the authority of science, of the integrity of scientists, and of the validity of the scientific method, and an active, practical effort, moved by intense feeling to combat and suppress them.
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> Scientists, in defending their cause, commonly overlook this. They assume that if they prove a thing true, it will, therefore, be accepted as true. This does not begin far enough back. They must first persuade people to accept proof itself as a criterion of truth. People who have never in their lives known anything on conclusive evidence, and whose most cherished beliefs are based on no evidence whatever, are not going to surrender fixed convictions on mere demonstration that they are mistaken, or accept anything unfamiliar on mere proof that it is true. In fact they have never been trained to ask whether anything is true or false.

Is the condition as bad as it was in 1925? Fundamentally there may have been no improvement. Specifically there has been some improvement in such instances where a revealing, far-reaching campaign was waged. Some enlightenment results so that the oncoming generation through curiosity learns more about it. I believe that the aftermath of the Tennessee antievolution case was, within a period of years, a somewhat more tolerant view of evolution teaching.

Obviously more and more science education must be developed. This guarantees no miraculous results, but is the only thing we can do.

The development of science has been so staggering that it is much faster than the public can assimilate. Indeed we might as well admit that proverbially anyone in science is able to encompass less and less of the areas of scientific development. The public accepts eagerly all those machines and gadgets science and technology invent, especially if they make life more comfortable, easy and colorful. And the public pays lip service to science. That is recognized and taken advantage of by all the advertisers blaring forth their products daily. Possibly people are under the belief that they are more scientific, when in truth they are unscientific in their evaluations.

This is a grave problem. Science teaching of the highest order is more and more mandatory in a democracy such as ours, in which people may have to vote

on matters entailing scientific questions. It is a serious matter when people are asked to vote as to whether the teaching of organic evolution be abrogated in schools, or whether they will or will not sanction health authorities in their communities to fluoridate their water supply. There needs to be clarifying in scientific matters which have impact upon the people. And the people must somehow learn to discriminate between the true science and the pseudoscience that is ever ready to claim them hostage.

As a practical aid in the dissemination of knowledge, I believe it is incumbent upon science teachers to spread their teaching further into the newspapers and magazines, the only way in which more people will be reached. There are scientific books and nature books galore. So few read them. There is no reason why newspapers cannot carry more scientific information. To be sure editors will have to cooperate more and the teacher-writers will have to do a superb job of clarifying without over-simplifying, and writing entertainingly without loss of scientific accuracy. It is no small task. Let us gird ourselves to the task.

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A NEW MEGASCOLECID EARTHWORM FROM MICHIGAN WITH NOTES ON ITS BIOLOGY

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Re-examination of specimens assigned by the writer (1956) to the species *Diplocardia singularis* (Ude) has shown that the Michigan form should be considered a distinct species. This oligochaete was collected from: (1) Section 8, Waterloo Township, Jackson County; (2) Section 12, Dexter Township, Washtenaw County; and (3) Section 20, Putnam Township (E. S. George Reserve), Livingston County. The Washtenaw County specimens were used in describing this species, named in honor of Professor H. R. Eggleston, Marietta, Ohio.

Diplocardia egglestoni n. sp.

Color, flesh to brown due to blood and internal pigmentation; integument colorless. Size, 70–90 by 1.2–2.0 mm. Somites, 75–110, average 106. Clitellum, XIII–XVII, cingulum type. Setal formula, $aa:ab:bc:cd = 16:6:13:8$, $dd = \frac{1}{2}c$. Genital field with paired seminal grooves on XIX in setal line *a*, often extended slightly on XVIII and XX. Spermiducal pores paired, on XIX. Prostate pores missing. Genital setae, setae *ab* of XVIII and XX nearly contiguous, sinuately curved, about two and one-half to three times longer than normal setae, without sculpturing, distal portion often twisted. Glandular areas, distinct and paired in 17/18 and 20/21 at setal line *ab*, occasionally in 18/19 and 19/20; setae of *ab* on XVIII and XX surrounded by rounded, glandular papillae. Oviducal pores, paired, on slightly depressed, oval, glandular area of XIV, anteromedian to *a*. Spermathecal pores on anterior margin of VII, VIII, and IX, slightly above setal line *a*; spermathecal setae not differentiated. Nephropores are intersegmental, regular, at setal line *d*. First dorsal pore, 8/9. Prostomium, epilobic, two-thirds.

Septa 8/9 and 9/10 considerably thickened; 7/8, 10/11, and 11/12 somewhat thickened. Testes and funnels, two pairs in X and XI; ovaries and funnels, one pair in XIII. Ovisacs absent. Seminal vesicles, two pairs, small; those of IX arising from ventro-lateral portion of 9/10, those of XII from ventro-medial aspect of 11/12. Seminal receptacles, three pairs in VII, VIII, and IX; duct and ampulla of equal length; diverticulum finger-like, on anterior surface of duct at the base of the ampulla; diverticulum about one-fifth as long as the entire seminal receptacle. Dorsal vessel single, last hearts in 12, no subneural trunk. Gizzards two, in V and VI. Esophagus, IX–XIV with distinct looping of the lumen wall; ciliated, longitudinal ridges beginning in XV; intestine expanding abruptly in XVII. Typhosole beginning in XVII. Meganephridial. Syntypes—in collection of United States National Museum (USNM Cat. No. 28714). Paratypes—in collection of author.

Diplocardia egglestoni stands very close to *D. singularis* (Ude), differing from the latter, and all other described species of the genus, in complete absence of prostate glands. Observed variations in shape and form of the spermathecal diverticulum cast doubt on the value of this structure for specific determination. Eisen (1899) described the diverticulum in *singularis* as "oblong"; Macnab and McKey-Fender (1955) used the expression "short stalk with a smoothly-rounded knob-like apex." In *egglestoni*, the diverticulum (fig. 1C) is short, fingerlike, and appressed to the stalk of the spermatheca; folding of the epithelium is not evident externally, but does appear in histological sections.

On the basis of the description by Eisen (1899), penial setae of *Diplocardia egglestoni* and *D. singularis* are similar; Macnab and McKey-Fender (1955), however, characterize the penial setae of *singularis* as "sinuately curved, but so slightly that the total effect is of a nearly straight seta." These setae, in *egglestoni*, are distinctly curved (fig. 1B), and from two and one half to three times longer

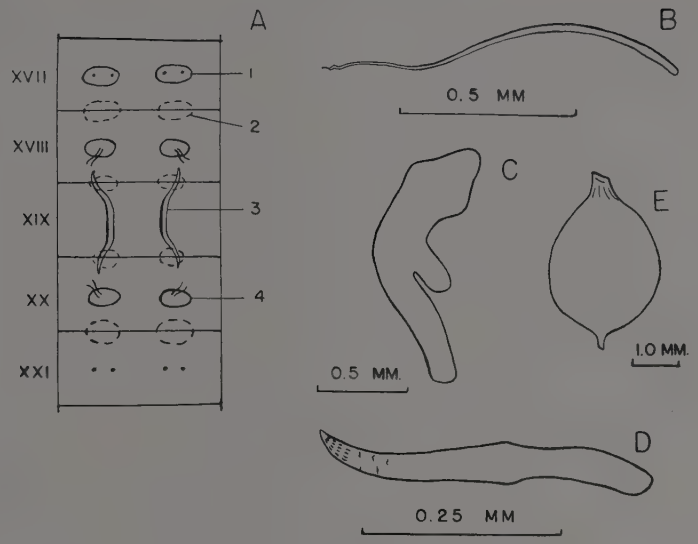

FIGURE 1

A. Genital field of *Diplocardia egglestoni*
   (1) Glandular papilla
   (2) Intersegmental papilla
   (3) Seminal groove
   (4) Papilla surrounding genital setae *ab*.
B. Genital seta *a* of XVIII.
C. Spermatheca of VIII.
D. Seta of spermathecal segment IX.
E. Oötheca of *D. egglestoni*.

than ordinary setae. No markings of any nature could be observed on the genital setae, whereas ordinary setae often show faint striae near the tip (fig. 1D). In young worms, glandular areas appear at 18/19 and 19/20 (fig. 1A); the identity of these areas is difficult to establish in older individuals as the entire genital field is then somewhat swollen.

Biology of Diplocardia egglestoni

All collections of *Diplocardia egglestoni* were made in upland forest soils (largely oak-hickory), or open grassy fields. None were ever encountered in wet, poorly-drained soil. *D. egglestoni* is a true soil species, forming irregular burrows throughout the upper soil; in open woods or fields, worms are usually found among grass roots near the surface. When disturbed, individuals assume a semirigid attitude and make no escape movements.

A population of *Diplocardia egglestoni* in Dexter Township, Washtenaw County, was studied for the period May 1, 1952, through May 30, 1953, in order to determine population density and variation in seasonal activity. At the peak of earthworm activity during May, 1953, ten soil samples, each measuring 50 X 50 X 50 centimeters, yielded an average of 14.7 *egglestoni* per plot. Similar samples, collected at biweekly intervals throughout the year, demonstrated the considerable control exercised by moisture and temperature on the biology of *Diplocardia egglestoni* insofar as seasonal periodicity was concerned.

The number of worms in the upper 50 centimeters of soil declined in June and, through July and August, they were virtually absent from the upper soil. The population increased in mid-September and remained fairly stable until December when a second major depression in population numbers occurred. The "normal" condition was resumed in late March.

This apparent cyclic behavior, as evidenced by changes in population density, was caused by migration of worms to the lower levels during periods of drought or soil freezing. The depth of such penetration can only be guessed, but a few individuals were recovered at 70 centimeters during July, 1952. *Diplocardia egglestoni* can enter a quiescent condition (*diapause* of some authors) similar to that found in the Lumbricidae. This state is induced by drought or cold and appears completely facultative.

In the dry summer period, it was the larger individuals which migrated downward beyond the sampling depth of 50 cm; smaller worms entered a quiescent condition, usually from 20 to 40 cm. The winter migration, probably because the soil was quite moist to all depths, involved departure of both large and small individuals from the upper soil layers. It should be pointed out that this responsiveness of *egglestoni* to moisture and temperature extremes is likely to vary somewhat under different conditions of drainage and soil texture; thus, precise thresholds and limits cannot be given.

Fully clitellate worms occurred only during May and June; it is probable however, that suitable soil moisture condition would have extended the reproductive period into the summer months. The only oötheca (cocoon) encountered in the entire period was collected on May 27, 1953, at a depth of four inches, among grass roots. It was subspherical in shape, opaque, and pale green in color; measuring 3.5 mm in length, and 2.5 mm in diameter (fig. 1E). The young worm was well developed at the time of collection, and emerged on the 18th of June; upon emergence it measured 15 mm in length.

A portion of this work was accomplished during the tenure of a Summer Faculty Research Fellowship awarded the writer by the Horace H. Rackham School of Graduate Studies, University of Michigan.

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Of Men and Marshes. *Paul L. Errington.* The Macmillan Company, New York. ix+150 pp. $4.50.

The poetic love story of a man for marshes, this book should appeal to all people who have appreciated the beauty of nature. It has great appeal and interest for the naturalist who has lived long enough in an area to understand it thoroughly. This is more than an appraisal of the role of marshes as harbors for wildlife, or of the role of men in managing marshes. It is a word picture of marshes by a man who sees the marsh world from the several viewpoints of a muskrat, a rail, a heron, a duck, a fish, and a cattail. When the viewpoint is compounded by a man who thinks in terms of vertebrate populations and ecologic changes, the picture is truly comprehensive.

THOMAS H. LANGLOIS

ECOLOGICAL OBSERVATIONS ON THE VIRGINIA PITCH-NODULE MOTH, *PETROVA WENZELI* (KEARFOTT), INCLUDING A NOTE ON ITS NOMENCLATURE

(LEPIDOPTERA, OLETHREUTIDAE)

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INTRODUCTION

The Virginia pitch-nodule moth, *Petrova wenzeli* (Kearfott), is a common insect which builds pitch nodules on twigs of Virginia pine, *Pinus virginiana* Miller. This nodule maker has been mentioned occasionally in taxonomic, faunistic, and economic literature, but ecological references to it are lacking.

The insect was studied in the field in Ohio during 1953 and in Maryland during 1955, and casual observations were made on it in Pennsylvania and Virginia. Study areas in Ohio were Waterloo and Hocking State Forests. In Maryland, 9 stations within a 20-mile radius of Washington, D. C., were used. All study and observation sites were naturally regenerated woodlands.

Determinations of *Petrova wenzeli* adults were made by the authors. Specimens reared during the study have been deposited in the U. S. National Museum, the collection of Cornell University, and the collections of A. E. Brower and C. P. Kimball. Eulophid and braconid parasites were determined respectively by B. D. Burks of the Insect Identification and Parasite Introduction Section, U. S. Department of Agriculture, and by C. F. W. Muesebeck of the U. S. National Museum. Pines were identified by the writers, with an occasional verification by E. L. Little, Jr., of the U. S. Forest Service Herbarium. Nomenclature of pines follows that of Rehder (1949).

IDENTITY

Up to the present, another name—*Petrova virginiana* (Busck, 1914)—has usually been used for *P. wenzeli*. Kearfott (Smith, 1910) mentioned the species first, using the name *Rhyacionia wenzeli*, but Kearfott's statements were not regarded as having nomenclatural significance. Under present International Rules, however, they constitute an "indication" (see Mayr et al., 1953; Chap. 11) and the name *Petrova wenzeli* therefore has priority.

To delimit exactly *P. wenzeli*, a lectotype must be designated because Kearfott did not designate any one specimen as the type. So far as known, nine specimens in the American Museum of Natural History comprised the entire *P. wenzeli* syntype series. All nine specimens bear printed red "TYPE" labels. A male and a female, presumably intended by Kearfott as "co-types," also have handwritten type labels. The male, with label data as follows, is hereby designated lectotype of *P. wenzeli*: "Glo. Co. N. J. iss. v. 15, TYPE, Collection of W. D. Kearfott, *Rhyacionia wenzeli* Kearf. Type ♂." The remaining members of the syntype series ("lectoparatypes") are as follows, with each bearing the label "TYPE, Collection of W. D. Kearfott": "Glo. Co. N. J. iss. v. 15, *Rhyacionia wenzeli* Kearf. Type ♀"; ♂ "Glo. Co. N. J. iss. v. 18"; ♂ "Glo. Co. N. J. iss. v. 23"; ♂ "Red Bank, N. J. v. 16"; ♂ "Glo. Co. N. J. iss. v. 20, *Evetria virginiana* Busck AB 1917"; ♀ "Glo. Co. N. J. iss. v. 20"; "Glo. Co. N. J. iss. v. 24" (lacking

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abdomen); and "Glouc. Co. N. J. iss. v. 12" (lacking abdomen). The American Museum of Natural History has donated two of the lectoparatypes with abdomens to the U. S. National Museum.

Clearly, Kearfott rather than Smith was responsible for the *Petrova wenzeli* indication. On page 17 Smith (1910) says ". . . the list has been written by me with such help as is specifically acknowledged, except that the microlepidoptera are almost entirely the work of Mr. W. D. Kearfott." Also, the abbreviations "Kearf." and "Kf." appear in the indication.

The type of *Petrova virginiana* and the newly designated one of *P. wenzeli* are undoubtedly conspecific. Grounds for conserving the better known name (*P. virginiana*) are weak: so far as known, the organism has been mentioned in a total of nine published articles—averaging only two mentions a decade—with the name *P. virginiana* appearing in eight, and the name *P. wenzeli* in three. It seems highly unlikely that a change could cause enough confusion to warrant overriding the rule of priority. The present synonomy is as follows:

Petrova wenzeli (Kearfott)

Rhyacionia wenzeli Kearfott *in* Smith, 1910: 538 (type: Gloucester Co., New Jersey; Amer. Mus. Nat. Hist.). —Heinrich, 1923: 23 (unintentional.) —Forbes, 1923: 439 (unintentional).

Evetria virginiana Busck, 1914: 145 (type: Falls Church, Virginia; U. S. Nat. Mus.).

Petrova virginiana, Heinrich, 1923: 23. —McDunnough, 1939: no. 6755.

Rhyacionia virginiana, Forbes, 1923: 439.

LIFE HISTORY

Petrova wenzeli individuals normally require two years to complete their life cycle. Eggs are laid in the spring. They hatch in early summer. Young larvae construct resinous nodules (fig. 2) on current shoots; in these nodules they feed and overwinter. The following spring, the larvae migrate from the first-year nodules and construct new nodules (fig. 3) on older twigs, usually at crotches. The larvae pass their second winter in these nodules. They pupate early the next spring, and a month or more later the adults emerge and begin laying eggs.

Egg stage.—The writers never found eggs in the wild, and the moths never laid fertile eggs in captivity. Moths in glass containers laid infertile eggs which were flat and oval. The dimensions of 6 eggs averaged 0.78 by 0.94 mm. Microscopic examination showed reticulations in their chorionic membranes. The least time between field observations of first adult emergence and first activity of newborn larvae was 11 weeks. The incubation period is estimated to be seven or eight weeks.

Larval stage.—The earliest dates that larval work of a new generation was found were July 31, 1953, in Ohio and July 17, 1955, in Maryland. In both observations, some nodules looked to be at least a week old. Larvae usually began feeding close to the terminal buds (fig. 2).

The way in which nodules are made was determined by microscopic examinations at various stages of their development, and by direct observation of larvae transferred to new twigs. Both first- and second-year nodules start as silken tents spun by the caterpillars over future feeding areas. A larva begins feeding within the area enclosed by the tent. As frass accumulates and resin exudes from the feeding site, the larva incorporates these materials into the tent. The first young larvae found in 1955 were transferred to new host trees. Twenty-four hours later, all that established themselves had completed tents and were beginning to carry resin to them. As the larvae grow, they enlarge their nodules by excavating the old nodule wall and building new annexes.

The earliest new nodules built by second-year larvae after their migration were seen on April 17, 1953, in Ohio and April 24, 1955, in Maryland. Second-year nodules were usually at crotches formed by twigs arising from larger branches (fig. 3); however, 11 percent of 44 second-year nodules were situated on twigs away from crotches. The numbers of new second-year nodules on the tops, sides, and bottoms of nonvertical twigs were about equal. Larvae do not feed much in the spring before migrating. Fresh frass was found in abandoned first-year nodules, but no nodule annexes built just before migration were ever found. New annexes are resinous and red in contrast to the whitish, weathered surface of older nodule parts. Larval migration distances along 14 twigs and branches ranged from 1 to 36 inches and averaged 11 inches. Two out of 16 larvae apparently had not migrated but were using the first-year feeding site for the second year's feeding.

The larvae preferred to feed on the tissue between the bark and the pith. After removing a portion of bark and exposing this tissue, they sometimes tunnelled beneath the bark for short distances, but they periodically removed more bark.

Two series of observations show that just after hatching and during spring migration, larvae crawling on twigs may drop to lower limbs. First, nodules occurred below the oviposition zone only when larvae could drop from overhead branches. (The oviposition zone begins at about 5 feet above the ground.) Second, only 38 percent of 94 branches supporting second-year nodules also had first-year nodules.

Although migration of *Petrova wenzeli* larvae may seem hazardous, it has survival value. Virginia pine tends to produce shoots in greater abundance and of smaller diameter than many other pines. The larvae of the nodule maker can pass their first year on very small shoots, but the larvae grow faster than the shoots. After one growing season the shoots are often too small to continue supporting the larvae; moreover, many of the shoots are dead. Newly hatched larvae are probably not able to penetrate the bark of twigs older than currently developing shoots. Migration at the start of the second growing season to crotches of larger twigs therefore fills the need for more food and better shelter. The ability of first-year larvae to live on very small shoots helps to maintain populations on Virginia pine, especially on old trees where shoot growth may be slight.

The age of the twigs supporting 41 currently inhabited second-year nodules was determined. Thirty-two percent of the nodules were on 1-year-old twigs including the node between 1- and 2-year-old twigs ("1–2"); 36 percent were on "2–3"; 22 percent on "3–4"; and 5 percent each on "4–5" and "5–6."

After their second winter, larvae resumed regular activity early. On March 5, 1955, in Maryland, most inhabited second-year nodules showed new annexes. However, second-year larvae became active for short periods during the winter on warm days. The writers broke open one nodule in early December, and the damage had been repaired by the next visit two weeks later. If the second-year larvae undergo a winter diapause, it is not an intense one.

Pupal stage.—Before pupation, the larva makes a pupal cell of frass and resin within the nodule. Pupal cells tended to be oriented more vertically than horizontally. At the outer end of the cell, the nodule wall is eaten away till there remains a thin, slightly translucent area of the nodule wall, about as big around as the pupa. The larva lines the cell with a silk mat which excludes resin and probably aids locomotion. The pupa lies with its head toward the exit. In Ohio, 8 individuals seen on April 18, 1953, had pupated. In Maryland, 7 of the 18 individuals seen on March 26, 1955, and 7 individuals seen on April 27 had pupated. The pupal period lasted about one month.

Emergence and adult stage.—In the laboratory, about half an hour elapsed from the time emergence activity of one individual was first noticed till the new moth took flight. A circular motion of the head, indicating abdominal twisting, was

discerned through cracks in the exit as the pupa worked. The silk mat engaging the backwardly directed abdominal spines doubtlessly increased the traction of the spines. After 15 minutes, the pupa broke through and moved out in a matter of seconds. An examination of many empty pupal cases protruding from nodules showed that pupae moved out far enough to clear the encased wings. Seconds after the pupa in the present example was out of the nodule, the moth broke out of the pupal case.

Incipient moth emergence was noted in Ohio (insectary) on May 10, 1953, and in Maryland (field) on May 1, 1955. The periods of insectary emergence from 2 collections of nodules producing 12 and 35 moths lasted 11 and 16 days. The sex ratio of 35 adults was 1.2 males to 1 female. Males tended to emerge ahead of females: in the insectary, median male emergence preceded that of females by 6 days.

A mean of 33 eggs per female was deposited by 4 unmated females in a glass jar. The minimum preoviposition period of this group of females was about 5 days.

As a species with a 2-year life cycle, *Petrova wenzeli* presents the possibility of isolation of the even- and odd-year maturing populations. At all study sites, even- and odd-year individuals were present on the same trees, and the two populations were also of about equal size. The degree of genetic isolation of two such populations is a function of the extent of mutability of the life cycle. Observations of this mutability in *P. wenzeli* are lacking, but its existence seems certain. No apparent anatomical differences between specimens from the two populations were found. An adult is illustrated in figure 1.

HOST SPECIFICITY

The insect's striking host specificity for *Pinus virginiana* among the pines growing naturally in its range has been brought out in another paper (Miller and Neiswander, 1956). The literature contains host records for only *Pinus virginiana* (Busck, 1914; Doane et al., 1936; Heinrich, 1923; Miller and Neiswander, 1956; Schaffner, 1950; Smith, 1910; and U. S. Dept. Agric., 1953 and 1956). It is likely that Polivka and Houser's (1936) report of Virginia pine being infested by *Petrova comstockiana* (Fernald) actually involved *Petrova wenzeli* (Miller and Neiswander, 1956). There is a close resemblance of the color pattern of the *P. wenzeli* adult's forewing to that of the mature staminate flower of its host, and the adult flight period is concurrent with pollen bearing.

Jack pine, *Pinus banksiana* Lambert, was found infested with *Petrova wenzeli* at the one place where the writers saw this pine growing within the range of *P. wenzeli*. At Beltsville, Maryland, a few jack pine trees averaging about 10 feet tall had some nodules. Only one adult insect was successfully reared from the jack pine. This specimen was positively identified as *P. wenzeli*.

Attempts to induce oviposition and subsequent development on caged trees failed. More than 20 adults were introduced in various experiments into a 320 ft^3 gauze cage containing 9 young pine trees, but reproduction never took place. Twenty-one recently hatched larvae and 20 1-year-old larvae were transferred to the experimental pines, but none survived to pupation although about one-third of both groups succeeded in building new nodules. The caged pines were as follows: *Pinus virginiana*, *P. taeda* Linnaeus, *P. nigra* Arnold, *P. rigida* Miller, *P. densiflora* Siebold and Zuccharini, *P. resinosa* Aiton, *P. echinata* Miller, *P. silvestris* Linnaeus, and *P. strobus* Linnaeus.

VERTICAL DISTRIBUTION

In sparse Virginia pine stands, trees less than 5 feet tall were never found supporting *Petrova wenzeli* nodules. Apparently, oviposition does not take place at heights less than 5 feet. In the following discussion, the term "oviposition

zone" designates heights above this level. On trees which were taller than 5 feet and whose crowns also reached the ground, second-year nodules were found as low as 1 foot above the ground. Occasionally, saplings less than 5 feet tall were found to contain second-year nodules, but such trees were always growing very close to larger trees. The occurrence of nodules below the oviposition zone on such saplings and on tall trees can be explained by the dropping of larvae discussed earlier.

No upper limit to the oviposition zone was found. In Maryland, the crowns of a dozen felled Virginia pine trees at three places were examined. Nodules were present in the crown of every tree. Two of the fellings were in pure stands of Virginia pine while the third was in a mixed hardwood-Virginia pine forest.

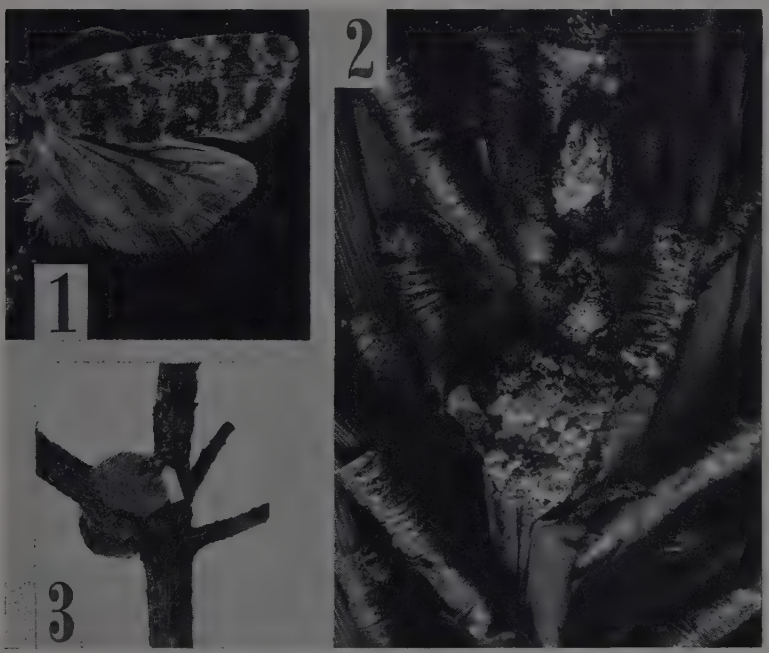

FIGURE 1. *Petrova wenzeli* adult from Ohio. Dark areas of the forewing are rust colored and the lighter markings are silvery white.

FIGURE 2. A new first-year *Petrova wenzeli* nodule on Virginia pine.

FIGURE 3. A second-year *Petrova wenzeli* nodule on Virginia pine with an empty pupal case (arrow) protruding. The second-year nodule has also been illustrated by Busck (1914).

Diameters of the examined trees ranged from 8 to 24 inches and annual rings counted from stump sections placed their ages between 25 and 75 years.

POPULATION DENSITY

Petrova wenzeli population levels seem to fluctuate very little: practically no variation in population density was noted among the 24 infestations observed in 4 states during this study. Also, high population levels have never been reported in the literature. A typical density is that reported by U. S. Dept. Agric. (1953) for an Ohio infestation. Of 21 trees between 5 and 8 feet tall sampled in a young

understocked stand of pure Virginia pine, 8 exhibited inhabited second-year nodules. Six of the trees had one nodule. Two trees had two and three nodules each. Many general observations suggest that the number of developing insects per tree is proportional to the extent of the crown area within the oviposition zone.

EFFECT ON HOST

The larvae feed first on needle bases, then on bark and cortex of twigs. Seven shoots infested by first-year larvae were observed for needle damage. Up to three needle clusters per shoot had tiny round holes through the sheaths indicating direct injury to needles. Still more needle clusters on each shoot had been injured after the direct needle feeding period by incidental feeding during expansion of the nodules. First-year larvae may also injure buds. In a sample of 13 infested shoots, 3 showed that 1 or more buds had been fed upon.

Many shoots attacked by first-year larvae die. Vigor seems to determine the fate of infested shoots. About half of infested lateral shoots were killed whereas a much smaller proportion of infested terminal shoots was killed.

Second-year larvae feed on that portion of the cortex beneath their nodules. The extent of injury caused by this feeding depends largely on the diameter of an attacked branch. The greatest injury seen was where the cortex had been removed 90 percent of the way around the branch. Up to 75 percent of branch circumference was often found with cortex destroyed. Cortex removal kills outright less than 1 percent of infested stems; however, it weakens branches and thereby contributes to breakage.

Doane et al. (1936) and Schaffner (1950) have mentioned the species briefly in treatises on economic insects.

MORTALITY

The caterpillar was commonly parasitized by *Hyssopus* spp. (Eulophidae). *Hyssopus* specimens from several places in Ohio were identified as *H. evetriae* (Girault) while specimens from Maryland were identified as *H. thymus* Girault. One caterpillar parasitized by *Agathis pini* (Muesebeck) (Braconidae) was found in Ohio. At least two successive *Hyssopus* generations (overwintering and one or more summer) attacked second-year larvae, with no appreciable difference in parasitization rate being observed in Ohio and Maryland. Spring observations of 44 larvae in new second-year nodules showed 14 percent parasitization, and winter observations of 83 larvae showed 7 percent parasitization. Both species of *Hyssopus* occurred externally and in aggregations of several individuals per host.

Nodule predation occurred sometimes at all study sites, but at two places in Maryland, birds preyed on an unusually large proportion of the pupae and mature larvae. A total of 50 second-year nodules examined at these sites on March 26, 1955, showed 56 percent recent predation. The attacked nodules contained solitary holes with occasional peck marks nearby. The size of most of the holes suggested a bird with a small, slender bill. The most likely suspect was the Carolina chickadee, *Parus carolinensis* Audubon (Beal et al., 1941).

Examination of 57 nodules in Ohio and Maryland just after moth emergence showed that 14 percent mortality from undetermined causes took place during the final 3 months of the life cycle.

ORIGIN AND GEOGRAPHIC DISTRIBUTION

The closest relative of *Petrova wenzeli* appears to be *P. albicapitana* (Busck), the northern pitch-nodule moth. The ecology of *P. albicapitana* (Turnock, 1953) is very similar to that of *P. wenzeli*, and specimens of the two strikingly resemble each other. The principal host of *P. albicapitana* is jack pine, a close relative of Virginia pine (Duffield, 1952). Noteworthy are these facts: first, that jack pine is the only species besides Virginia pine known as a host for the Virginia pitch-

nodule moth, and second, that introduced Virginia pine in Michigan is attacked by *P. albicapitana*. *Petrova wenzeli* and *P. albicapitana* are geographically isolated from each other by the isolation of their host species (Little, 1949). Isolation and speciation of the insects probably occurred by dispersal of adults from the range of one of the two pines to the range of the other. Dispersal across the *Pinus virginiana-Pinus banksiana* gap followed by interbreeding may be going on at the present time. Dispersal across this gap would probably have to take place by "mass flights" (Wellington, 1954).

The known distribution of the Virginia pitch-nodule moth is shown in figure 4. Three sources of distribution information were used: museum specimen records, the writers' own records (rearing and identifying the adult or noting work of the larva), and published records. Inquiries for specimens and distribution records were directed to eight museums and private collections. Authentic records were obtained from the U. S. National Museum, the Academy of Natural Sciences of Philadelphia, and the American Museum of Natural History. The writers

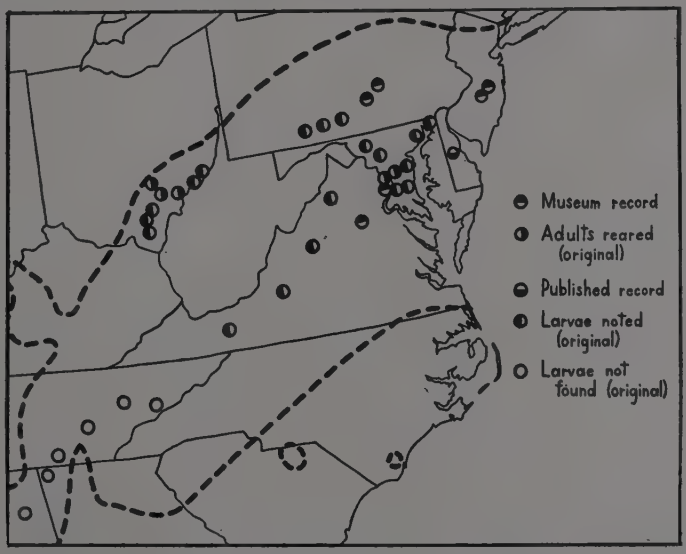

FIGURE 4. Distribution of records for *Petrova wenzeli*. The broken line represents the range limits of Virginia pine (after Little, 1949).

examined the specimens for each positive report and thereby eliminated several false records that were due to misidentifications. A wider distribution than could be shown on a point map has been reported for Delaware (U. S. Dept. Agric., 1956).

The listing of *Petrova wenzeli* on Nantucket and Marthas Vineyard Islands, Massachusetts, (Jones and Kimball, 1943) was based on misidentified specimens. J. F. Gates Clarke rechecked the Marthas Vineyard specimens which are in the U. S. National Museum and found they belonged to a different genus. The fact that Virginia pine is not included in Rice's (1946) list of tree species on Nantucket suggested the possibility of this error.

SUMMARY AND CONCLUSIONS

1. The biology of the Virginia pitch-nodule moth, *Petrova wenzeli* (Kearfott), was studied in Ohio during 1953 and in Maryland during 1955. The name of the species is herein changed to *P. wenzeli* from *P. virginiana* (Busck).

2. Under natural conditions, *P. wenzeli* attacks only Virginia pine, *Pinus virginiana* Miller, and its larvae build resinous nodules. The insect is known to occur in that part of the range of Virginia pine lying north of the 37th parallel.

3. The life cycle is normally two years long. Even- and odd-year generations occurred on the same trees. Larvae hatch during July and feed on new shoots. The following spring the partly grown larvae migrate to older twigs and branches. Pupation takes place the next March and April, and the adults are out in May.

4. Adults caged over young trees did not reproduce.

5. Oviposition occurs at heights ranging from the tops of old Virginia pine trees down to about 5 feet above the ground. Individuals developing below the 5-foot level probably drop from overhead branches just after hatching or during migration in the spring.

6. Population densities of the insect are low and seem to fluctuate little.

7. Larval feeding injures needles, twigs, and sometimes buds. Early feeding may kill shoots that are not growing vigorously. Later feeding destroys cortical tissue and weakens branches without killing them outright.

8. Larval parasitization is low and nearly all caused by either *Hyssopus thymus* Girault or *H. evetriae* (Girault). Insectivorous birds may sometimes eat a large proportion of the pupae and mature larvae.

9. *Petrova wenzeli* and *P. albicapitana* (Busck) probably evolved from a common population following dispersal of adults across the gap separating the host species.

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Teaching Science to the Ordinary Pupil. *K. Laybourn* and *C. H. Bailey.* Univ. of London Press, Warwick Square, London. E.C. 4. 415 pp. $10.00.

This book was prepared for use of pupils in the schools of Manchester, England, by two competent men, one a Chief Inspector of Schools, the other a Head of Science Department in a Training College. Guided by some principles which were formulated by a committee of teachers whose concern is with the ordinary pupils (not the very bright or very stupid pupils), the effort is directed to relate content and methods of teaching science to the interests and abilities of those being taught.

Believing that learning follows interest, and that the primary function of education is that of fostering interest, the lessons were made attractive and useful. Subjects taught include the following: air, burning and respiration, living things, physiology, water, heat, electricity, sound, sight, stars and space, force and movement, balance and stability, machines and engines, soil and reproduction.

Emphasis is placed on the skill of teachers in using tools and materials of everday life, rather than special items, to illustrate points of discussion. To assist teachers in this phase of their work, the text is illustrated with a total of 535 line drawings, and there is a list of apparatus and materials used in the experiments in an appendix. There has been great ingenuity shown in the selection of subject matter and in presentation of the lengthy series of experiments. Undoubtedly the ordinary pupil can be given considerable interest in doing the things suggested and in so doing will learn many facts about the things he will see and do throughout life. Perhaps this is an exposure to the methods of science and to some facts pertaining to various fields of science. It should make better citizens but it will not make many scientists.

THOMAS H. LANGLOIS

ONE NEW SPECIES AND ONE SUBSPECIES OF CERAMBYCIDAE FROM TEXAS

(COLEOPTERA)

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Methia lata n. sp.

Female.—Robust, elongate, dark brown throughout, each elytron with elongate brownish yellow patch back of scutellum and a diagonal stripe of same color extending from humeral angle toward suture on basal third; antennae and both surfaces densely pubescent.

Head as wide as widest part of pronotum; eyes coarsely granulated, separated above by a little more than width of second segment of antennae; surface densely, coarsely punctured; a median depression on front; antennae extending over one segment beyond apices of elytra when laid over back, ratio of length of segments 1 to 11, 4:.5:7.5:7.2:5.2:5:4:3:2.6:2:2.2.

Pronotum wider than long, widest in middle, wider at base than at apex, constricted at base and apex; sides broadly rounded; disk convex, with a small broad tubercle each side of middle in front of scutellum and a faint one each side in front of middle; surface in middle shining, sparsely, finely punctured; stridulatory plate of mesonotum polished, without median ridge. Scutellum coarsely punctured.

Elytra near base widest part of insect, extending well beyond last ventral segment; sides subparallel in basal third, somewhat constricted about middle, then converging to obtusely rounded apices; disk of each elytron with three costae; surface between costae scabrous with punctures more evident on basal third.

Beneath with abdomen shining, minutely punctured; fifth segment modified. Posterior tarsi with first segment equal in length to the two following segments united.

Length: 14.4 mm.; width 3.4 mm.

Holotype ♀ taken at light in Chisos Mountains, Texas, June 30, 1957, in collection of author.

This species is close to *M. mormona* Linell. It is a much broader beetle, with stouter scape and shorter last antennal segment.

Psapharochrus quadrigibbus lucidus n. subsp.

This is the form which I referred to (1944) as occurring on mesquite at Brownsville, Texas. The entire insect is lighter in color than specimens found in Ohio and Pennsylvania and the white transverse bands are darker.

♀ holotype, Brownsville, Tex., May 7, 1934, J. N. Knull. Paratypes of same sex from same locality, May 25, 1934; May 23 and June 1, 1939 and Apr. 4, 1950, all taken by D. J. and J. N. Knull, in collection of author. Holotype length 12.5 mm. and width 5.3 mm.

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LIGHT DIFFRACTION BY SINGLE STRIATED MUSCLE FIBERS†

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In two preceding reports (Meyer-Arendt, 1957a, b), the scattering of light has been discussed that originates from single tissue cells or cell componenets. Two sets of information can be obtained by this microscattering technic: first, information about the turbidity of the sample shown by a more diffuse scattering; secondly, information about any regularity, if present at all, in the arrangement of the underlying structures. For these studies two narrow and almost parallel light beams were projected into the test specimen. One of them was directed onto the cell; the other served as a reference. The scattered light has been observed through an ordinary, high power microscope, at a plane kept in a constant distance of 106 μ above the specimen.

The objective of the investigations presented here is to study light diffraction patterns effected by striated muscle fibers. In particular, such patterns were attempted to obtain from minute portions within one single muscle fiber. Similar measurements have been done by Buchthal and Knappeis (1940), while earlier Ranvier (1874) and later-on Neumann (1951) operated in a macroscopic range, using whole sections through muscle tissue.

TECHNIC

The technic used has been essentially the same as reported previously. Additionally, however, following a suggestion by S. Inoué, the interference patterns in the back focal plane of the microscopic objective were recorded.

Light of 546.1 mμ wavelength is obtained from a high pressure mercury lamp and directed into a pinhole 125 μ in diameter. An image of this pinhole is projected, by an aplanatic objective of 50 mm focal length, into the muscle fiber under investigation. By closing down the iris diaphragm of the aplanate to f : 18, faint lateral maxima can be saved from being overlighted by the intense zero order light beam. Since most diffraction maxima were fairly distinct, no reference beam was needed. A Zeiss planachromatic oil immersion objective, x 100, was used for observing the pattern. The interference patterns in the back focal plane of this objective were recorded through an auxiliary microscope (telescope), as used for aligning phase contrast objectives. Photomicrographs were taken by an attachment camera on Kodak Process Ortho Sheet Film.

RESULTS

Striated muscle fibers are built of alternating lighter "I," and darker and denser "A" discs, the A bands having a higher refractive index. In the investigations reported, around 4 to 5 A and I bands were covered by the incident light beam, thus causing diffraction patterns from this number of periods. Specimens stained either with iron-hematoxylin or hematoxylin-eosin were used. The diffraction patterns seen in the back focal plane are substantially similar to those observed previously between specimen and objective. They consist essentially of a

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series of maxima, the arrangement of which is perpendicular to the direction of the bands within the muscle fiber (fig. 1). The distances between the maxima are related to the spacing of the bands. Perpendicular to these maxima, another series of faint maxima can be recognized. These are caused by the fibrillar structure of the muscle fiber. It may be of interest to note that these latter maxima have not been recorded before. This may be explained by the fact that these maxima are faint and of very low light intensity, compared with the distinct maxima caused by the cross striations. Even those are not easily recorded.

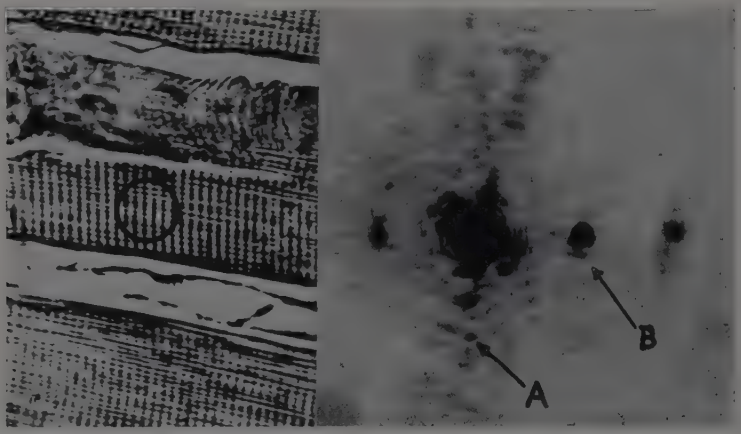

FIGURE 1. Left: Photomicrograph of human striated muscle fibers. Magnification about x 750. The encircled area designates the size of the incident light beam. Right: Primary interference pattern from an area as shown at left, recorded from the back focal plane of the microscopic objective. A—fibrils; B—cross striations.

It can be shown, thus, that light diffraction patterns can be obtained from minute areas within one single muscle fiber. Such patterns seem to show more details than have been reported previously.

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BIOGRAPHIES OF GEOLOGISTS

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Ten years ago, one of us published *A list of books on the personalities of geology* in this journal (vol. 47, 192–200, 1947). At the time it was noted that such a list was certainly incomplete, and the intervening years have shown that this was decidedly an understatement. Since then we have found many more such books, new ones have been published, and interested friends (especially J. V. Howell and F. S. Colliver) have suggested important additions. Only 78 biographies were included originally, and since some 132 more can now be added, it seems worthwhile to present a more complete listing, even though it is probably still incomplete. We have added brief comments on all the biographies except those few we have not been able to examine. In the original list, books of geologists' travels, histories of geology, and "miscellaneous" books were included. These are omitted here, only biographical and autobiographical books being admitted. Even with this restriction, choice in some instances has not been easy. As in the first list, we have included only items that have appeared as books, deliberately excluding all but a very, very few biographical notices, memoirs, and obituaries that were published in various journals.

All those seriously interested in geology and its branches as a profession or avocation cannot fail to win something from the reading of their predecessors' struggles and triumphs. Who can work with the great quarto volumes of the *Palaeontology of New York* without wondering about the character of a man with enough fortitude to produce them? Who can notice the constant allusions to Sir Charles Lyell in hundreds of geological works without wondering how he lived and worked? Who can read of the first geological exploration of the Grand Canyon of the Colorado without a thought to the motives that pushed John Wesley Powell into the unknown? Who can read *The Old Red Sandstone* without wondering what sort of geologist could write such elegant and lucid prose? Who can discover that a mineral, such as dolomite, was named for one Deodat Dolomieu without wondering who this man was to merit such an honor? And who can contrast the great volumes on the zoology of the United States Exploring Expedition with the many editions of *A System of Mineralogy* without wondering at the versatility of James Dwight Dana? Or at the even greater versatility of Louis Agassiz—from ice to jungle exploration, from fossil fish to embryology?

We hope that geologists and other scientists will find this compilation a useful guide to books about the men who have labored on the main fabric or in the dark corners of the vast edifice of minerals, volcanoes, glaciers, fossils, mountains and rivers that is geology.

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1895.—Factual account of the life and work of Ehrenberg, famous for his pioneer studies of the coral reefs of the Red Sea and on Foraminifera and other protists.

ESCHER VON DER LINTH, Arnold. 1807–1872. Heer, O. *Arnold Escher von der Linth, Lebensbild eines Naturforschers.* Friederich Schulthess, Zurich, 1893.—Swiss geologist who did pioneer work in Alpine stratigraphy and structure.

EVANS, Lewis. 1700–1755. Gipson, L. H. *Lewis Evans, to which is added Evans' A Brief Account of Pennsylvania Together with Fascimiles of His Geographical, . . . Essays, Numbers I and II . . . an Analysis of a General Map of the Middle British Colonies. . . .* Historical Society of Pennsylvania, Philadelphia, 1939.—Evans was a surveyor, engineer, engraver, traveller and map maker. He made many important geological observations and gave the first description of physiographic divisions of the United States. This finely printed book includes facsimiles of Evans' Map and "Analysis."

FORBES, Edward. 1815–1854. Wilson, G. and Geikie, A. *Memoir of Edward Forbes,* F.R.S. Macmillan and Co., Cambridge and London, 1861.—Edward Forbes was a pioneer in the study of animal ecology and geography.

FORBES, James David. 1809–1868. Shairp, J. C.; Tait, P. G.; and Adams-Reilly, A. *Life and Letters of James David Forbes,* F.R.S. Macmillan, Londón, 1873.—Forbes, professor of natural philosophy at Edinburgh, later at St. Andrews, is famous for his studies of glaciers.

FORSTER, Westgarth. 1772–1835. Nall, W. (*Memoir of*) *Westgarth Forster,* in Forster, Westgarth, *A Treatise of the Section of the Strata from Newcastle-upon Tyne to Cross Fell with remarks on Mineral Veins . . . Third edition, revised and corrected to the present time by the Rev. W. Nall, M.A. . . .* Andrew Reid, Newcastle: Edward Stanford, London, 1883.—Forster was a mining engineer and geologist (financially unsuccessful) who first recognized cyclic sedimentation in Carboniferous rocks, produced elaborate stratigraphic columns and described relation to lead ore to stratigraphy and structure. His work is mainly known from the second edition (1821) as the first (1809) is very rare. The three editions vary considerably. Forster deserves a modern study and evaluation.

FRENCH SAVANTS. Lacroix, A. *Figures de Savants.* 2 vols., Gauthiers-Villars, Paris, 1932.—Short studies of the lives and work of 31 French mineralogists and geologists, from Desmarest to Haug, with portraits and facsimiles of handwriting. Important source of information on French scientists.

GEIKE, Archibald. 1832–1924. Geikie, A. *A Long Life's Work, an Autobiography.* Macmillian, London, 1924.—Geike was an outstanding figure in British geology, long director of the Geological Survey of Great Britain; prolific biographer and writer on history of geology.

GEIKE, James. 1839–1915. Newbiggin, M. I., and J. S. Flett. *James Geikie, the Man and the Geologist.* Oliver and Boyd, Edinburgh, 1917.—Brother of Archibald, professor at Edinburgh, glacial and structural geologist.

GILBERT, Grove Karl. 1843–1918. Davis, W. M. *Biographical Memoir Grove Karl Gilbert 1843–1918.* Memoirs of the National Academy of Sciences, vol. 21. Washington, 1927.—A geological biography of possibly America's greatest geologist by another great geologist who himself deserves a book length biography. One of the three outstanding American biographies.

GOETHE, Johann Wolfgang. 1749–1832. Magnus, R., with a foreword by Gunther Schmid, translated by Heinz Norden. *Goethe as a Scientist.* Henry Schuman, New York, 1949.—(Translation of *Goethe als Naturforscher.* Leipzig, 1906). Contains a chapter on Goethe's contribution to geology and mineralogy. Some asserted his priority in the idea of evolution and of the Ice Age.

GREENLY, Edward. 1861–1951. Greenly E. *A Hand Through Time: Memories—Romantic and Geological; Studies in the Arts & Religion, and the Grounds of Confidence in Immortality.* Thomas Murby & Co., 2 vols. London, 1938.—At once autobiography, biography of Mrs. Greenly and sketches of geologists and geologic activities of the time. Keen geological observations and maudlin biography. Must be seen to be believed.

GRESSLY, Amand. 1814–1865. Rollier, L. *Amand Gressly's Briefe: Lettres d'Amand Gressly, le Geologue Jurassien.* Soc. Jur. D'Emul., Actes, 1911.—The only book-size work on Gressly, whose study of the Swiss Jurassic is the foundation of paleoecology and the stratigraphic concept of facies. Gressly is almost unknown in America!

GUNN, John. 1801–1890. Woodward, H. B., ed. *Memorials of John Gunn.* Norwich, 1891.—Rector of Irstead, keen amateur geologist, leader in early geological studies in Norfolk, best known for his work on the Cromer Forest Bed.

HAAST, Sir Julius von. Haast, H. F. *The life and times of Julius von Haast.* Gov't Printer, New Zealand. n.d.

HALL, James. 1811–1898. Clarke, J. M. *James Hall of Albany, Geologist and Palenotologist, 1811–1898.* Albany, 1921. (reprinted 1924).—One of the best biographies of a scientist. Excellent study of the great Paleozoic paleontologist and lively account of the early days of geologic study of the classic ground in New York and adjoining areas. Much material on contemporary associates and geological activities.

HAMMOND, John Hays. 1855–1936. Hammond, J. H. *The autobiography of John Hays Hammond.* 2 vols. Farrar & Rinehart, New York, 1935.—Interesting and well-written accounts of mining ventures over the world by the Freiberg-trained successful engineer and consultant of the select group of Pumpelly, Penrose, and Hoover.

HARRISON, Benjamin. 1837–1921. Harrison, E. R. *Harrison of Ightam.* Oxford Univ. Press, London, 1928.—The Robert Dick of Kent, discoverer of the "eoliths." A must for all students of the Pleistocene.

HARTT, Charles Frederick. 1840–1878. Menezes, C. A. de *Biographia do Professor Carlos Frederico Hartt.* Rio de Janeiro, 1878.—Brief study of the first professor of geology at Cornell University and pioneer in the geology of Brazil.

Wright, A. H. *Pre-Cornell and Early Cornell II. Letters to C. F. Hartt, first Professor of Geology at Cornell. A cross-section of the Agassiz Period.*—Letters of 1863–1879 to Hartt, by many important scientists which pertain to science of the time.

HEILPRIN, Angelo. 1853–1907. Pollock, G. *Michael Heilprin and his sons.* Dodd, Mead, New York, 1912.—Michael was editor of the *Nation.* Louis, the encyclopedist, was his first son; Angelo, the geologist, his second.

HEIM, Albert. 1849–1937. Brockmann-Jerosch, Marie; Heim, A.; and Heim, Helene. *Albert Heim, Leben und Forschung.* Wepf & Co., Basel, 1952.—Definitive biography and summaries of scientific work of the great authority on Alpine tectonics and glacial geology.

HITCHCOCK, Edward. 1793–1864. *Reminiscences of Amherst College, historical, scientific, biographical and autobiographical; also of other and wider life experiences.* Bridgman and Childs, Northampton, Mass., 1863.—Professor of geology at Amherst, sometime state geologist of Massachusetts and Vermont. Did excellent work in many kinds of geology, including early work on glacial drift.

HOBBS, William Herbert. 1864–1953. Hobbs, W. H. *An Explorer-Scientist's Pilgrimage, the Autobiography of William Herbert Hobbs.* J. W. Edwards, Inc., Ann Arbor, 1952.—Hobb's activities in several fields of geology, in geography and in international affairs make us wish his book had been longer and more detailed.

HORNER, Leonard. 1785–1864. Lyell, K. M. *Leonard Horner.* 2 vols., Women's Printing Society, Ltd., London, 1890.—Horner was a Scottish geologist and merchant, the father-in-law of Charles Lyell.

HOUGHTON, Douglass. 1809–1845. Bradish, A. *Memoir of Douglass Houghton.* Raynor & Taylor. Detroit, 1889.—Includes reprints of geological writings of Houghton, pioneer Michigan geologist, who was also physician and explorer.

Rintala, E. K. *Douglass Houghton, Michigan's Pioneer Geologist.* Wayne Univ. Press, Detroit, 1954.—Supplements Brandish somewhat in personal details of Houghton.

HUBBARD, Bela. 1814–1896. Hubbard, B. *Memorials of a Half-Century in Michigan and the Lake Region.* Putnam's, New York, 1888. Early Michigan geologist, naturalist and meterologist. Pleasant, rambling reminiscences.

HUMBOLDT, Alexander von. 1769–1859. Anonymous. *The Life, Travels and Books of Alexander von Humboldt.* With an Introduction by Bayard Taylor. Rudd & Carelton, New York, 1859.—There are many biographies of this German geologist, traveller, explorer, botanist and philosopher who wrote 74 books on these subjects. This is not the best one.

Assing, L., ed. *Letters of Alexander von Humboldt to Varnhagen von Ense, from 1827 to 1858* (Trasl. F. Kapp). Rudd and Carleton, New York, 1860 (from 2d German edition).—Interesting but of little geological import.

Banse, E. *Alexander von Humboldt. Erschliesser einer neuen Welt.* Wissenschaftliche Verlagsgeschellschaft M.B.H., Stuttgart, 1953.—Straightforward biography; emphasizes Humboldt's geographical importance.

Bruhns, K., ed. *Life of Alexander von Humboldt* (Transl. by J. and C. Lassell). Longman, Green, London, 2 vols., 1873.—Compiled in commemoration of the centenary of Humboldt's birth by J. Lowenberg, R. Arc-Lallemant, and A. Dove.

Buchner, W. *A. von Humboldt, ein Lebensbild.* Lahr, 1882.

De Terra, H. *Humboldt; the life and times of Alexander von Humboldt,* 1769–1859. Alfred A. Knopf, New York, 1955.—Well-written modern work on Humboldt's "long and fabulous life" with some summary of his scientific work; stresses American connections.

Klenche, H. and G. Schlesien. *Lives of the brothers Humboldt, Alexander and William,* transl. by Juliette Bauer. Ingram, Cooke & Co., London; Harper, New York (1854), 1852. *Eine biographisches Denkmal.* A. von Humboldt. Leipzig, 1859.

Wittwer, W. C. *A. von Humboldt, sein wissenschaftliche Leben und Wirken.* Leipzig, 1860.

HUTTON, James. 1729–1797. Playfair, J. *Biographical Account of the Late Dr. James Hutton, F.R.S., Edin.* Royal Soc. Edinburgh Trans., vol. 5, pt. 3, pp. 39–99, 1805; also collected works of John Playfair, Esq., vol. 4, pp. 33–118, 1822.—Sympathetic biography stressing Hutton's methods of geologic observation and induction.

Various Authors. *James Hutton* 1726–1797. *Commemoration of the 150th Anniversary of his Death.* Proc. Sect. B. Royal Soc. Edinburgh, vol. 63, pt. 4, 1950.—Hutton, "The Founder of Modern Geology," deserves a modern biography: the two listed are excellent for the areas they cover.

HUXLEY, Thomas Henry. 1825–1895. Huxley, L. *Life and Letters of Thomas Henry Huxley.* 2 vols., Macmillan and Co. London. 1900. (Also American edition 1901).—Huxley, celebrated biologist and forensic scientist, was the friend of Darwin and champion of the theory of evolution.

JEFFERSON, Thomas. 1743–1826. Martin, E. T. *Thomas Jefferson: Scientist.* Henry Schuman, New York, 1952.—Jefferson's scientific activities were remarkable. His interests in vertebrate paleontology are well known.

JOLY, John. 1857–1933. *Reminiscences and anticipations.* Fisher Unwin, London, 1920.—Professor of geology and mineralogy at the University of Dublin, Joly is perhaps best known to geologists as the author of the salt-content method of estimating the age of the oceans. This volume contains only scattered reminiscences.

JORDAN, David Starr. 1851–1931. *The days of a man: being memories of a naturalist, teacher and minor prophet of democracy.* World Book Co., Yonkers-on-Hudson, 1922.—Vivid autobiography of the founding president of Stanford University and great student of fossil and recent fish.

JUKES, Joseph Beete. 1811–1869. Jukes, Miss., ed. *Letters and extracts from the addresses and occasional writings of J. B. Jukes.* Chapman & Hall, London, 1871.—Professor in the Royal College of Science in Dublin, and local director of the Geological Survey of Ireland. An early student of coral reeefs.

JUNGHUHN, Franz. 1809–1864. *Gedenkboek Franz Junghuhn.* Nijhoff, 'S-Gravenhage, 1910.—Pioneer geologist and botanist in the Dutch East Indies.

KANE, Elisha Kent. 1820–1857. Elder, W. *Biography of Elisha Kent Kane.* Childs & Peterson, Philadelphia: Sheldon, Blakeman & Co., New York, 1868.—The Arctic explorer who made some geological and glaciological observations. His own books on explorations are more interesting than the biography.

KARPINSKY, Alexander P. 1847–1936. Lichkov, S. L. *Karpinskiy i Sovremennost.* Akademii Nauk SSSR, Moscow, 1946.—Brief outline of Karpinksy's life and work (in Russian).

KEITH, Arthur. 1866–1955. *An autobiography.* Wells and Co., London; Philos. Library, New York, 1950. Revealing account of a great comparative anatomist and student of fossil man.

KING, Clarence, 1842–1901. Various authors. *Clarence King Memoirs* (*The Helmet of Mambrino.*) Putnam, New York, 1904. (Publ. for King Memorial Comm. of Century Ass'n.)—A series of fulsome articles about this complex person who inspired many friendships. King was first director of U. S. Geological Survey. He flowered early and enjoyed life.

KOWALEVSKY, Vladimir Onufrieyevich. 1842–1883. Davidaschvili, L. S. *Biography,* in Russian. Acad. Sci., Moscow and Leningrad, 1946.—Life and work of the Russian vertebrate paleontologist.

LAMARCK, J. B. P. A. de M. de. 1744–1829. Packard, A. A. *Lamarck, the Founder of Evolution, his Life and Work, with Translation of his writings on organic Evolution.* Longmans, Green, New York, 1901.—Apparently the first book devoted to the life and work of the celebrated zoologist, paleontologist, and evolutionary pioneer.

Roule, L. *Lamarck et l'Interpretation de la Nature.* E. Flammarion, 1927.—An important evolution of Lamarck's work.

LECONTE, Joseph. 1823–1901. Armes, W. D., ed. *Autobiography of Joseph LeConte.* Appleton, New York, 1903.—Very readable reminiscences of the student of Louis Agassiz and early professor of geology at the University of California.

LEHMANN, Johann Gottlob. 1660–1709. Freyburg, B. v. *Johann Gottlob Lehmann (1719–1767) Ein Arzt, Chemiker, Metallurg, Bergmann, Mineraloge und grundlegender Geologe.* Universitatsbund Erlangen, 1955.—Exhaustive biography, genealogy, and bibliography of a man of whom little detail has been known. Lehmann made important observations in several sciences and especially on kinds of mountains, classification of strata and origin of ores.

LESLEY, J. Peter. 1819–1903. Ames, M. L. *Peter and Susan Lesley.* 2 vols., Knickerbocker Press, New York, 1909.—Geologist turned minister turned geologist. Consultant, state geologist of Pennsylvania, expert cartographer. Fine example of old-fashioned, slow-paced, but gradually revealing life and letters.

LHWYD, Edward. 1660–1709. Gunther, R. T. *Life and Letters of Edward Lhwyd,* Early Science in Oxford, vol. 14. University Press, Oxford, 1945.—Second keeper of the Ashmolean Museum; acquaintance of all the scientific men of his time; author of first English book of fossils.

LINNAEUS, Carl. 1707–1778. Fee, A. L. A. *Vie de Linne.* Paris, 1832.

Stoever, D. H. *The life of Sir Charles Linnaeus.* Transl. by J. Trapp from the Swedish. London, 435 p., 1794.—An early study of the great systematist whose work is the starting point for modern systematics of fossil and living organisms.

Fries, T. M. *Linne: lefnadsteckning af Th.M. Fries.* Fahlcrantz & Co., Stockholm, 2 vols. 1903.—According to Hagberg, a complete picture of the external life of Linne.

Linnaeus: the story of his life (transl. by B. D. Jackson). Whitherly, London, 1923.

Hagberg, K. H. *Carl Linne, "Le Roi des Fleurs."* (transl. from Swedish by Hammer and Metzger.) "Je Sers," Paris, 1944.—An attempt to reveal the real man behind the celebrated systematist.

———. *Carl Linnaeus* (English translation by Alain Blair), Johathan Cape, London, 1952.

Smith, J. E. *A selection of the correspondence of Linnaeus and other naturalists.* Longmans, Hurst, Rees, etc., London, 2 vols., 1821.—Important source material on Linnaeus.

Carl v. Linne als Natorforscher u. Arzt. ed. by Svensk. Akad. Wissen., Jena, 1909.

LITTLE, George. 1838–1924. *Memoirs of George Little.* Tuscaloosa, 1924.—Professor of geology at the University of Mississippi.

LOGAN, William Edmond. 1798–1875. Harrington, B. J. *Life of Sir William E. Logan.* John Wiley & Sons, London, 1883.—Good biography of a pioneer in Canadian geology; first director of Geological Survey of Canada.

LONGYEAR, Edmund J. 1864–1954. Longyear, E. J. edited by Grace N. Nute. *Mesabi Pioneer, Reminiscences of Edmund J. Longyear.* Minnesota Historical Society, St. Paul, 1951.—Pioneer in Iron Range exploration and development.

LYELL, Charles. 1797–1875. Lyell, Mrs., ed. *Life, Letters, and Journals of Sir Charles Lyell, Bart.* 2 vols., Murray, London, 1881.—Thoroughly readable selections from the letters and journals of the celebrated British geologist, scientific descendent of Hutton and expounder of uniformitarianism.

Bonney, T. G. *Charles Lyell and Modern Geology.* Macmillan, New York, 1895.—Based upon the "Life and Letters," but a more connected biography.

LYMAN, Benjamin Smith. 1835–1920. Gonpei, K. *Biography of Benjamin Smith Lyman.* Sanseido, Tokyo, 1937.—A short appreciation of Lyman's life and geological work by one of his many Japanese friends.

MCGEE, William John. 1853–1912. McGee, E. R. *Life of W. J. McGee.* Farley, Iowa. 1915.—McGee was a self-educated geologist, anthropologist, hydrologist and scientific organizer. He was not noted for modesty.

MACLURE, William. 1763–1840. Morton, S. G. *Memoir of William Maclure, Esq.* Academy of Natural Sciences of Philadelphia, printed by T. K. and P. G. Collins, 1841.—Brief (37 pp.) biography of the so-called "Father of American Geology." It is high time for a comprehensive biography of Maclure, altho his thoroughly Wernerian work was no better than that of Volney, Mitchill, and others.

MACOUN, John. 1831–1920. *Autobiography of John Macoun, M.A., Canadian explorer and naturalist.*—Field Nat. Club, Ottawa, 1922.

MANTELL, Gideon Algernon. 1790–1899. Curwen, E. C. *The Journal of Gideon Mantell, Surgeon and Geologist,* covering the years 1818–1852. Oxford Univ. Press. London, 1940.—The revealing journal of the discoverer of Iguanodon, especially interesting for its candid remarks on famous geologists of the early 1800's.

Spokes, S. *Gideon Algernon Mantell.* John Bale, Sons & Danielsson, Ltd., London, 1927.—Life and letters of the surgeon-geologist; includes long American correspondence.

MARCY, Oliver. 1820–1899. *In memoriam . . . Oliver Marcy, LL.D.* n.p., n.d.—Professor of geology at Northwestern University.

MARSH, Othniel Charles. 1831–1899. Schuchert, C. and C. M. LeVene. *O. C. Marsh, Pioneer in Paleontology.* Yale Univ. Press, New Haven, 1940.—An excellent companion volume to Osborn's "Cope." Marsh and Cope, the outstanding American vertebrate paleontologists, were bitter rivals.

MICHELL, John. 1724–1793. Geikie, A. *Memoir of John Michell.* Cambridge Univ. Press, 1918.—Michell was "Fellow of Queen's College in Cambridge, 1749, Woodwardian Professor of Geology in the University, 1762" who understood continuity of strata and folded structures.

MILLER, Hugh. 1802–1856. Bayne, P. *The Life and Letters of Hugh Miller.* 2 vols. Gould and Lincoln, Boston, 1871. (Also London edition 1871).—A long, prosy, dull, poorly-documented, and generally unsatisfactory biography of the author of the classic, *The Old Red Sandstone*—Scottish stonemason, poet, editor, geologist, paleontologist and celebrant of the Old Red fishes.

Bingham, W. *The Life and Writings of Hugh Miller, an oration . . . G. W. Wood,* New York, 1859.—Unimportant.

Brown, T. N. *The Life and Times of Hugh Miller.* Rudd and Carleton. New York, 1859.—A poor biography.

Leask, W. K. *Hugh Miller.* Oliphant, Anderson and Ferrier, Edinburgh, 1896.—Excellent brief biography.

Miller, H. *My Schools and Schoolmasters; or, the Story of My Education.* Thomas Constable and Co. Edinburgh. 1858. (other editions, including Boston, 1863).—The best account of the early life of Hugh Miller.

Watson, J. L. *The life of Hugh Miller.* 1880.
The centenary of Hugh Miller, being an account of the celebration held at Cromarty on 22nd August, 1902. Univ. Press, Glasgow, 1902.

MITCHELL, Elisha. 1793–1857. Phillips, C. *A Memoir of the Rev. Elisha Mitchell, D.D., Late Professor of Chemistry, Mineralogy & Geology in the University of North Carolina.* Chapel Hill, 1858.—Mitchell was all-round naturalist; wrote textbooks in geology and died exploring present Mt. Mitchell.

MITCHILL, Samuel Latham. 1764–1831. Hall, C. R. *A Scientist in the Early Republic, Samuel Latham Mitchill,* Columbia Univ. Press. New York, 1934.—A fair study of one of the very important early "all-round" scientists of America, friend and helper of many others; the first real contributor to the geology of New York State.

MURCHISON, Roderick Impey. 1792–1871. Geikie, A. *Life of Sir Roderick I. Murchison.* 2 vols., John Murray, London, 1875.—Well-written, like all of Geikie's works. Murchison was one of the great figures of the formative years of geology and elaborator of the Silurian System.

NOPCSA, Franz Baron. 1877–1933. Tasnadi, A. K. *Granz Baron Nopcsa.* Ungarn. Naturwiss. Mus., Budapest, 1945.—Life, letters, and scientific work of the famous Hungarian student of fossil reptiles.

ORTON, Edward. 1828–1899. (various). *In Memoriam, Edward Orton, Ph.d., LL.D., Addresses delivered at the Ohio State University, Sunday, November 26, 1899.* Printed by the University, Columbus, 1899 (?).—Includes among other essays a biographical sketch (anon.) and essay on Orton as geologist by G. K. Gilbert. Orton was teacher, administrator, geologist and gentleman.

OWEN, David Dale. 1807–1860. Hendrickson, W. B. *David Dale Owen, Pioneer Geologist of the Middle West.* Indiana Historical Collections, vol. 27, Indiana Historical Bureau, Indianapolis, 1943.—Owen was one of the most tireless and able of the early American geologists.

OWEN, Richard. 1804–1892. Owen, R. *The Life of Richard Owen.* 2 vols., Murray, London, 1894.—The letters and journals of the great English 19th Century anatomist and vertebrate paleontologist, celebrated for his deductions from fragmentary fossil bones.

PALISSY, Bernard. 1510–1590. Audiat, L. *Bernard Palissy.* Fontanier, Saintes, 1864.—A local memorial to their famous fellow townsman.
La Rocque, A. *The Admirable Discourses of Bernard Palissy.* Univ. of Illinois Press, Urbana, 1957.—A critical translation of Palissy's great work of 1580, with extensive notes and introductory essay dealing with Palissy's life and scientific contributions.
Morley, H. *Palissy the Potter, the life of Bernard Palissy of Saintes.* Chapman & Hall. London. 2 vols. 1852: Ticknor, Boston, 1853. (Other eds., 1855, 1865, 1878.—Imaginative biography of the famous maker of "rustic figulines" and important forerunner of inductive science who had modern notions of origin of salt, of ground water and artesian wells and partly modern ideas of origin of fossils. Morley includes long passages from Palissy's works, varying from free translations to paraphrases.

PENGELLY, William. 1812–1894. Pengelly, H. *A Memoir of William Pengelly of Torquay, F. R. S., Geologist.* Murray, London, 1897.—Schoolmaster and keen "amateur" geologist.

PENROSE, Richard Alexander Fullerton, Jr. 1863–1931. Fairbanks, H. R. and Berkey, C. P. *Life and Letters of R. A. F. Penrose Jr.* Geological Society of America, New York, 1952.—Comprehensive biography of a man who not only made princely bequests to the Geological Society of America and American Philosophical Society, but was also a great scholar, teacher, scientific and business organizer, traveler, and positive person.

PERCIVAL, James Gates. 1795–1856. Ward, J. H. *Life and Letters of James Gates Percival.* Ticknor and Fields, Boston, 1866.—The complex history of a complex character; physician, poet, lexicographer, linguist, first co-state geologist of Connecticut and second state geologist of Wisconsin.
Legler, H. E. *James Gates Percival, an anecdotal sketch and bibliography.* Milwaukee, 2 vols., 1901.

PLAYFAIR, John. 1748–1819. Playfair, J. G. Biographical account of the Late Professor Playfair in vol. 1, pp. xi-xxvi, of *Collected works of John Playfair, Esq. with a Memoir of the Author.* Edinburgh. Arnold Constable and Co. 1822. 4 vols.—Playfair was professor of mathematics and later of natural philosophy at Edinburgh; friend of James Hutton and author of the classic "Illustrations of the Huttonian Theory of the Earth," 1802.

PLAYFAIR, Lyon. 1818–1898. Reid, W. *Memoirs and Correspondence of Lyon Playfair, first Lord Playfair of St. Andrews.* Harper and Brothers, New York and London, 1899.—Early organic chemist (studied under Liebig) who was chemist to Geological Survey, knew royalty and all the great and was politically rewarded. Distant connection of John Playfair.

POWELL, John Wesley, 1834–1902. Darrah, W. C. *Powell of the Colorado.* Princeton Univ. Press. Princeton, N. J. 1951.—Excellent and completely documented biography with geological emphasis.

Gilbert, G. K., ed. *John Wesley Powell; a Memorial to an American Explorer and Scholar.* Chicago. 1903. (Reprinted, with slight changes, from *The Open Court,* vols. 16, 17.)—Powell was one of the founders of the United States Geological Survey, famous for his geological explorations in the West.

Stegner, W. E. *Beyond the Hundredth Meridian; John Wesley Powell and the Second Opening of the West.* Houghton Mifflin. Boston, 1954.—Well documented biography stressing Powell's arid land studies, and his relation to history of the times.

PRESTWICH, Joseph. 1812–1896. Prestwich, Mrs. Joseph. *Life and Letters of Sir Joseph Prestwich.* William Blackwood and Sons, London and Edinburgh, 1899.—Curiously reticent biography of geologist who was first a business man and late in life was professor at Oxford.

PUMPELLY, Raphael. 1837–1923. Pumpelly, R. *My Reminiscences.* 2 vols. Henry Holt, New York, 1918.—One of the most readable of scientific autobiographies, well-known for its real adventure and anecdotes of this pioneer economic geologist.

RAFINESQUE, Constantine Samuel. 1783–1840. Rafinesque, C. S. *A Life of Travels.* Chronica Botanica, vol. 8, 1944. (1st ed., Phila., 1836).—Fascinating self-portrait of one of the eccentrics of natural history, prodigious laborer among the hosts of new animals, plants, and fossils of America.

Call, R. E. *The Life and Writings of Rafinesque.* John P. Morton and Company Printers to the Filson Club, Louisville, 1895.—The standard biography of Rafinesque.

Fitzpatrick, T. J. *Rafinesque, a sketch of his Life, with Bibliography.* Historical Department of Iowa, Des Moines, 1911.—Brief but excellent biography and bibliographic description of 941 Rafinesque publications and 134 items referring to him.

RAMSAY, Andrew Crombie. 1814–1891. Geike, A. *Memoir of Sir Andrew Crombie Ramsay.* Macmillan, London, 1895.—Excellent for its summaries of work of the period and portraits of geologists of the time.

RAO, B. Rama. 1893–. *Recollections of an Indian geologist.* Mysore Geologists' Assoc., Bangalore, 1953.—One of India's distinguished geologists, Director of the Mysore Geological Department and later Director of the Indian Bureau of Mines.

RASPE, Rudolph Erich. 1737–1794. Carswell, J. *The Prospector, being the Life and Times of Rudolph Erich Raspe.* Cresset Press, London, 1950.—Best known as author of "Baron Munchausen's Travels," Raspe was scholar, antiquarian, scientist—one of the first to recognize igneous origin of basalt in 1769—author, mining manager, expatriate, expelled Fellow of the Royal Society and petty scoundrel.

RAY, John. 1628–1705. Derham, W. *Select Remains of the Learned John Ray. M. A.* and *F. R. S., with his Life.* George Scott, London, 1740.—Summary of Ray's life with some additional material. Ray is known primarily as a botanist, but his geological observations and writings—not sufficiently recognized by historians of geology—were extensive, penetrating and essentially modern.

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Raven, C. E. *John Ray Naturalist, his Life and Works.* University Press, Cambridge, 1942. (second ed. 1950).—The definitive biography and summary of Ray's scientific contributions. A great scientific biography.

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A STUDY OF THE TRYPSINLIKE PROTEASE OF THE ADULT STABLE FLY, *STOMOXYS CALCITRANS* (L.)[1]

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INTRODUCTION

For the past few years a study of the digestive mechanisms of the adult stable fly, *Stomoxys calcitrans* (L.), has been under investigation in this laboratory. The initial work, which dealt with the qualitative identification of the midgut digestive enzymes and the quantitative stimulation of protease by feeding has been reported previously (Champlain and Fisk, 1956). The present study is in part a continuation of Dr. Champlain's work on the qualitative characterization of the trypsinlike activity of the stable fly and in part an attempt to purify the trypsinlike component of the midgut brei. Purification was attempted by fractionation methods as well as by zone electrophoresis on paper and on starch gels.

TECHNIQUES AND EQUIPMENT

Rearing of the stable flies.—Stable flies were reared according to the method of Champlain, Fisk, and Dowdy (1954). Pupae were taken from the breeding culture and held in a refrigerator for a week to ten days as needed. Flies for laboratory use were reared from these pupae in small rearing cages. After emergence, the adults were maintained on a ten percent sucrose diet for three days. Then the sugar solution was removed and the adults were starved for 24 hours. A meal of fresh whole citrated bovine blood was fed to the flies from a blood soaked cotton pad. After a given time interval, usually 12 hours, the cage was placed in a deep freezer. When the flies were immobilized by cooling, they were transferred to small plastic cups which were partially filled with ice and water. Midguts were dissected from these flies. The 12 hour period following feeding was shown by Champlain (1955) to coincide with the interval of maximal proteolytic activity in the midgut. Following dissection, the midguts were homogenized in buffer at pH 7.8 and stored in a deep freezer.

Enzyme activity.—The trypsinlike activity was determined by an adaption of the method of Charney and Tomarelli (1947) using a sulfanilamide azocasein substrate dissolved in Sigma "7–9" *Tris* buffer (2 amino-2-hydroxymethyl-1, 3-propandiol) (Sigma Chemical Company, St. Louis, Missouri) adjusted to pH 7.8. The azocasein substrate was used in the reaction mixture at a concentration of ten mg per ml. The homogenate-substrate reaction mixtures were incubated in a water bath at 40°C. A zero time and a final time determination were made on this reaction mixture. This consisted of treating one ml aliquots of the reaction mixture with two ml of ten percent trichloracetic acid. This precipitated the unhydrolyzed protein. After centrifuging, two ml of the supernatant were removed and added to three ml of 0.5 N sodium hydroxide. Alkalinization intensified the color of the solution. A Klett-Summerson Photoelectric Colorimeter, equipped with a 420 millimicron filter, was used to measure the amount of light transmitted by this solution. A water blank was treated in the same manner to determine the amount of chromophore released from the substrate nonenzymatically. Usually this was negligible.

The activity of the reaction mixture was determined by correcting the final

[1]Part of a dissertation submitted by the senior author in partial fulfillment of the degree Doctor of Philosophy.

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Klett reading to compensate for the nonenzymatic hydrolysis and the initial amount of hydrolysis products present in the solution. Activity could be reported in terms of Klett units per ml of homogenate by appropriate dilution factors. In a few cases activity is reported in terms of mg of substrate hydrolyzed. This was determined by use of a standard curve based on the alkalinization of serial dilutions of the substrate. When the substrate is made alkaline, the color density of the solution is the same as if the substrate had been completely hydrolyzed and the soluble chromophore made alkaline for colorimetric analysis.

A second substrate described by Tomarelli, Charney, and Harding (1949) was used in the same manner. This substrate, sulfanilic acid azoalbumin, was used in the reaction mixture at a concentration of 12.5 mg per ml.

Paper electrophoresis.—A *Misco* Paper Electrophoresis Apparatus (Microchemical Specialties Company, Berkeley, California) with a D. C. Power supply (Biophysical Instruments Company, supplied by A. H. Thomas Company, Philadelphia, Pennsylvania) was used to study the electrophoretic mobility of the midgut homogenate. Whatman No. 1 filter paper, supplied in a roll one and one half inches wide, was cut into 14 inch long strips and placed on the tray. The ends of the paper were allowed to dip into the buffer in the end cells. The homogenate was applied with a *Spinco* Applicator (Specialized Instruments Corporation, Division of Beckman Instrument Company, Inc., Belmont, California) on a pencilled line across the center of each strip. The electrophoresis apparatus was placed in a refrigerator held at 8°C in order to avoid over-heating the protein materials due to the resistance of the paper to the applied voltage.

Starch gel electrophoresis.—Plastic trays were constructed from *Plexiglas* to have dimensions of 30 by 5 by 2 cm. A glass plate was cut to serve as a cover. The trays were filled with starch gel and connected to the end cells of the *Misco* paper electrophoresis apparatus by means of filter paper wicks. Both *Tris*-citrate and barbital buffers were used in the formation of the starch gels.

The starch gel was prepared from commercial corn starch. A slurry of *Cream* corn starch (Staley Manufacturing Company, Decatur, Illinois), 10 gm in 20 ml distilled water, was added to 100 ml of boiling *Tris*-citrate buffer. Six gm of *Super Cel* and 80 ml of distilled water were added. This mixture was allowed to boil for ten minutes while being continually stirred. The final molarity of the buffer in the gel was 0.03. After the gel had cooled slightly, it was poured into the plastic trays. Then they were covered with the glass plate and placed in the refrigerator overnight.

Protein determinations.—Both the Hengar Micro-Kjeldahl (Hengar Company, Philadelphia, Pennsylvania) and the Folin-Ciocalteu protein determination (Lowry et. al., 1951) methods were used to check the protein nitrogen and the protein content of the homogenates. Armour bovine albumin (Fraction V) served as the empirical standard for the Folin-Ciocalteu determination.

EXPERIMENTAL

Comparisons of activity of homogenates from male and female stable flies.—Male and female flies were separated following feeding with citrated bovine blood. The flies were dissected ten hours later, and the trypsinlike activity of the separate homogenates was determined. In these experiments the homogenates contained the same number of midguts per ml. The dry weight of an aliquot of the homogenate was determined after drying in an oven at 110°C. The reaction mixtures contained one half gut per ml and had a buffered azocasein concentration of ten mg per ml. After incubation at 40°C for 90 minutes enzymatic activity was stopped by precipitation with ten percent trichloroacetic acid. Reagent blanks as well as boiled enzyme blanks were utilized. Six replications were used and the activity reported in Klett units (table 1).

Proteolytic activity of the diverticulum.—The diverticulum or crop of the stable

fly consists of a posteriorly directed ventral diverticulum suspended by tissue from the anterior part of the midgut. In blood-fed flies it was seen as a contracted, opaque, bilobed saclike structure connected through a slender tube to the proventriculus. But, in a few cases, blood was found in the diverticulum following a blood meal. During a series of approximately 200 dissections, ten blood-filled diverticula were found and were prepared as a homogenate in pH 7.8 *Tris* buffer. In a similar manner a homogenate was prepared from ten non-blood-filled diverticula. The trypsinlike activity of both these homogenates was compared with a homogenate of midguts following an incubation of one hour at 40°C with azocasein at ten mg per ml. The concentrations of the reaction mixtures and the resulting Klett readings were as follows: 3.33 blood-filled diverticula per ml—4 Klett units; 3.33 non-blood-filled diverticula per ml—0 Klett units; and 0.5 midgut per ml—50 Klett units. These results are interpreted as being negative for both types of diverticula and, of course, positive for the midguts.

Activity characteristic determination.—The activity characteristic has been used to compare the activity of enzymes from various sources. Lin and Richards (1956) have used the activity characteristic to compare proteinases from the American cockroach and the house fly. In determining this parameter of stable fly midgut protease the formula substitution method was used (Neilands and Stumpf, 1955). The degree of hydrolysis of the azocasein substrate was determined by comparing the Klett readings of the enzyme substrate reaction mixture with a standard curve. Alkalinization of serial dilutions of a known amount of substrate was used to produce the standard curve.

TABLE 1

Trypsinlike activity of male and female stable flies

Test	Sex	R_{90}*	Mg Dry Weight†
1.	Male	29	0.0172
	Female	26	0.0181
2.	Male	24	0.0183
	Female	20	0.0181
3.	Male	41	0.0150
	Female	40	0.0140
4.	Male	25	0.0216
	Female	23	0.0212
5.	Male	22	———
	Female	23	———
6.	Male	30	———
	Female	33	———

*Activity in terms of Klett units following 90 minutes of incubation.
†Milligrams of dry weight per two midguts.

TABLE 2

The effect of temperature on activity

Temperature	Activity in[1] Klett units	Mg Substrate hydrolyzed per hour
30	18	0.126
35	30	0.211
40	45	0.316
45	67	0.470
50	69	0.484
60	40	0.281

[1]Average of four replications.

By means of reaction mixtures containing ten mg of substrate and two-thirds of a midgut per ml, the amount of substrate hydrolysis was determined over a series of temperatures ranging from 30 to 60°C (table 2). A combined homogenate was required to avoid differences in proteolytic activity that exist between different groups of flies. Four replications were employed at each temperature. The averaged readings are reported in the table. Thermal inactiviation was found to predominate above 50°C with the one hour incubation period.

Determination of the order of reaction.—The order of reaction was determined by plotting the activity of a homogenate azocasein reaction mixture at various

time intervals. The buffered substrate and homogenate concentrations were ten mg and one gut per ml of reaction mixture, respectively. Aliquots of the reaction mixture were removed from the incubating reaction mixture after 0, 30, 45, 60, 90, and 120 minutes. These aliquots were analyzed for hydrolysis of the substrate. Figure 1 is a plot of the substrate hydrolyzed per milliliter of reaction mixture for the different time periods of incubation. Four replications of this experiment were made.

Effect of dialysis on activity.—A midgut homogenate was prepared, and a known volume of it was dialyzed against distilled water overnight in the cold. Then the proteolytic activity of the dialyzed portion and of the nondialyzed homogenate was determined using one ml aliquots. Also one ml aliquots of the dialyzed and nondialyzed homogenates were analysed by Hengar Micro-Kjehldal for protein nitrogen.

Following this, the activity of the separate homogenates, dialyzed and nondialyzed, were related to units of protein nitrogen. Since the activity per mg of protein nitrogen was found to be the same in both cases no reason was found to suspect the presence of a dialyzable activator.

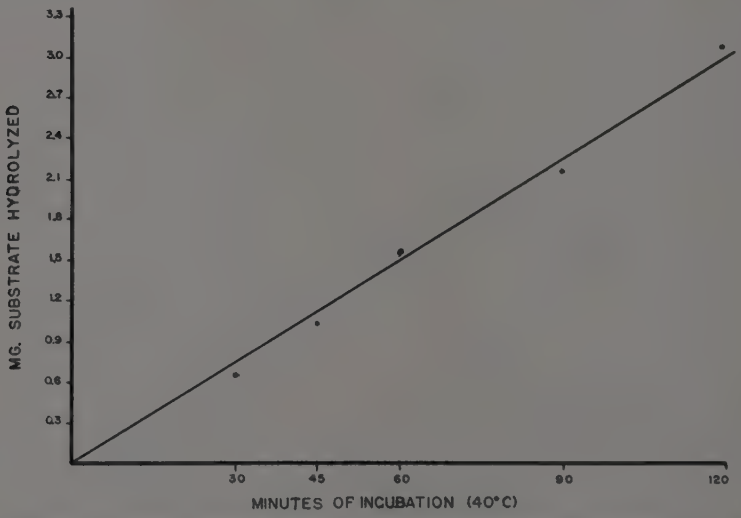

FIGURE 1. Activity recorded in terms of Klett units following incubation of 0.5 ml of homogenate with two ml of azocasein substrate after incubation at 40° C for varying periods up to 120 minutes.

Effect of selected ions, antibiotics, and toluene on activity.—In addition, no effect on activity was found when the dialyzed homogenate reaction mixture was made 0.02 M with respect to the following ions: calcium, magnesium, sodium, chloride, and fluoride. The effect of three antibiotics was tested on the reaction mixture. Penicillin G (Squibb) was found to have no effect on the reaction, while dihydrostreptomycin (Squibb) and terramycin (Pfizer) were found to alter the substrate, apparently resulting in nonenzymatic cleavage. When toluene was tried as a preservative the substrate tended to decompose appreciably upon overnight storage in the refrigerator. This was especially undesirable since the hydrolyzed chromophoric group of the azocasein was soluble in the toluene layer and accumulated there.

Paper electrophoresis of the midgut homogenate.—Paper electrophoretic techniques were adopted from procedures used in the separation of human blood plasma proteins as suggested by Dr. Robert L. Wall (1956, personal communication). The equipment has been described above.

Barbital buffer, with an ionic strength 0.05 at pH 8.0, was placed in the end cells of the electrophoresis apparatus and the tray was put between the end cells. The buffer level was adjusted with a siphon before the paper strips were arranged on the tray with their ends dipping in the end cells. A line was drawn with a pencil across the center of the paper strips. Buffer was applied to the paper by means of a medicine dropper. Then the tray was covered with a glass plate and the direct current was applied to the electrodes. After three hours of equilibrating at 1.5 mamp per strip (approximately 500 vdc), the current was disconnected and approximately 20 μl of homogenate was placed on the pencilled line of each strip. Then the glass plate was replaced and the power, equivalent to 1.5 mamp per strip, was reapplied.

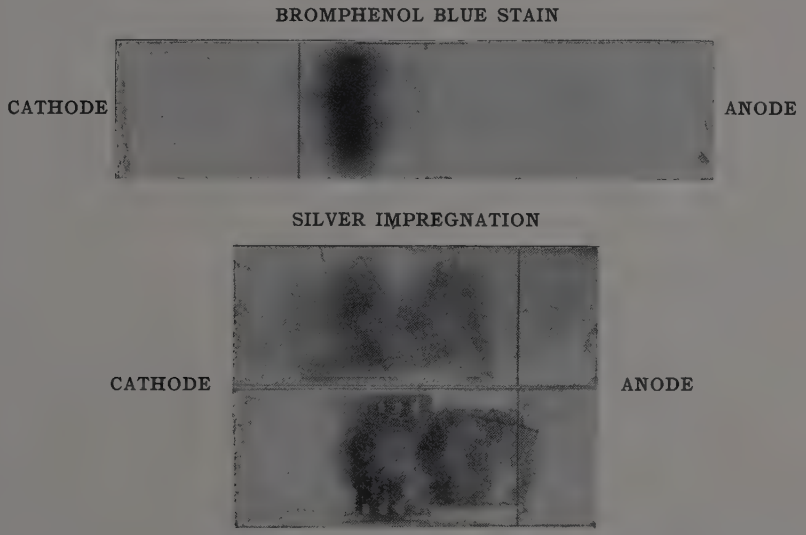

FIGURE 2. The strip stained with bromphenol blue illustrates the distribution of protein of the stable fly midgut homogenate, while the silver impregnated strips illustrate the distribution of the protease of the stable fly midgut homogenate, following paper electrophoresis.

Following electrophoresis of duplicate strips for 24 hours, one strip was used to determine the location of the protein while the other was used to test for proteolytic activity. Bromphenol blue staining identified the protein fractions (Wall, 1956, personal communication) while incubating the other strip with exposed and developed *Kodak 35 mm Plus X* film located enzyme activity. The exposed film was moistened with pH 7.8 *Tris* buffer and placed on top of the electrophoretic strip. The whole was sandwiched between two glass plates and incubated at 39°C for 45 minutes. Enzyme activity was detected by the hydrolysis of the gelatin from the film. This process released the silver particles which impregnated the paper. Figure 2 shows a bromphenol blue dyed strip and a strip stained with the free silver particles.

As indicated in figure 2, the enzymatic component exhibited cathodal movement

while the remaining protein fractions exhibited anodal migration. Although three bands of enzymatic activity could be located by use of the photographic film, either by the clearing of the film itself or by the impregnation of the silver in the paper, the enzymatic material apparently contained too little protein to stain with the bromphenol blue dye. No cathodal migration of the enzymatic material was found at either pH 7.6 or pH 8.6 with the barbital buffer.

Starch gel electrophoresis.—Bernfeld and Nisselbaum (1956) have used starch gel electrophoresis to separate proteins from mouse serum. This method was applied to the separation of the proteinase from the midgut homogenate of the stable fly. Bernfeld and Nisselbaum prepared a purified amylose for the starch gel. However, in the following experiments a satisfactory starch gel was formed from commercial *Cream* cornstarch as previously described. After the gel had cooled overnight in a refrigerator, a slot was cut across the gel in the center of the tray. This slot was of such a size that it could hold either one or two ml of homogenate, depending on the experiment. After filling the slot with the

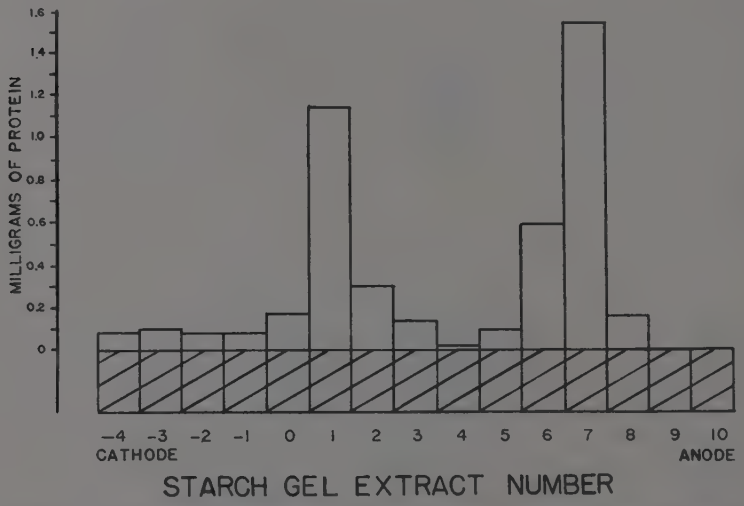

FIGURE 3. The shaded area represents the interference of the soluble starch in the Folin-Ciocalteu protein determination. The peaks of protein in the anodal sections 1 and 7 represent the location of the two proteins following starch gel electrophoresis.

homogenate, the tray was placed between the end cells of the paper electrophoresis apparatus and connected to them with filter paper wicks. The tray was covered with a glass plate and direct current applied so that each cell received 200 vdc at 12 to 15 mamp.

After 24 hours of electrophoresis, the tray was removed and the gel divided into cross sections of either one or one half cm in width. Each section of the gel was transfered to a separate centrifuge tube. Three successive extractions with 0.3 M *Tris* buffer at pH 7.8 were used to separate the protein from the gel. Each extraction consisted of adding three ml of buffer, shaking the tube manually for 30 seconds, centrifuging to throw down the starch granules, and, finally, pouring off the supernatant which contained the protein. The supernatant from each successive extraction of the individual starch sections was pooled. As a result

the protein contained in each section of the starch gel was transfered to a test tube in a measurable volume of buffer. Aliquots of the extract were used to test both enzyme activity and protein concentration.

It was found during trial runs, when four instead of three extractions were made, that successive extracts contained 53, 26, 16, and 5 percent of the total protein recovered. The Folin Ciocalteu protein determination was used to measure the amount of protein in the extract. A section of the gel which contained no protein was extracted to serve as a blank, since such soluble starch as remained in the extracts interfered in the Folin Ciocalteu test.

This procedure was capable of separating a protein mixture as illustrated by the following test. A solution composed of equal parts by weight of Armour bovine plasma fractions I (fibrinogen) and V (albumin) in 0.9 percent sodium chloride was placed on a starch gel after it had been prepared in the usual way. Following electrophoresis, at pH 8.6 in *Tris* buffer for 24 hours, the starch was

TABLE 3

Activity distribution following starch gel electrophoresis. Activity in Klett units per milligram of protein

Section Number	*Tris*-Citrate Buffer			Barbital Buffer
	pH 7.6	pH 7.6	pH 8.0	pH 8.0
(Cathode)				
−3	0	0	0	0
−2	0	0	0	91
−1	410	500	500	544*
0	690*	770*	838*	260
1	410	433	640	107
2	281	321	341	188
3	171	280	303	440*
4	267	287	436*	25
5	440*	333*	412	78
6	118	311	357	244*
7	187*	293	199	90
8	136	544*	158	45
9	40	300	150	0
10	0	222	0	0
11	0	0	0	0
(Anode)				

*Activity peak.

sectioned and extracted. When the amount of protein in each extract was measured by means of the Folin Ciocalteu procedure, 99 percent of the total protein was accounted for. It is obvious from figure 3, which illustrates the linear distribution of the protein in the gel, that the two fractions, I and V, exhibited different electromobilities.

In a further test the brei was placed in a prepared starch gel made with *Tris*-citrate buffer at pH 8.0. This brei had been previously dialyzed and lyophilized. Then after being diluted with water to a known volume, aliquots were tested for enzyme activity and protein content. On the basis of this information, the volume was adjusted so that the final protein concentration was equivalent to a two percent albumin solution.

Following electrophoresis of this homogenate, the starch gel was sectioned and extracted. Then aliquots of the extracts were tested for enzyme activity

and protein concentration. Since the volume of the extract was known, it was possible to calculate the protein and enzyme distribution in the starch gel. In addition, it was possible to determine the amount of purification by comparing the activity per mg of protein of the homogenate with the activity per mg of protein in the extracts.

Table 3 lists the relationships of activity per mg of protein of extracts from four starch gels. The degree of purification for the enzyme is given for each section of the starch gel. Inspection of this table reveals that no cathodal migration of the protein or enzyme material was found. This contrasts with the results of paper electrophoresis. The enzymatic distribution consistently appeared in several peaks but the peaks were not similarly distributed in the different gels.

One gel was made up to have the same concentration of the barbital buffer as was used in the paper electrophoresis. This gel, following extraction, exhibited no cathodal migration of enzymatic material.

TABLE 4

Protein distribution following starch gel electrophoresis (Tris-Citrate Buffer, pH 7.6)

Sect. No.	Milligrams of Protein Per Section		Combined Extracts		
	Gel No. 1	Gel No. 2	Sections Combined	Total mg Protein Remaining	Activity per mg Protein
(Cathode)					
−5	0.00	0.06			
−4	0.00	0.06			
−3	0.06	0.16			
−2	0.32	0.51	−1, −2	2.75	0
−1	0.52	0.84			
0	2.75	1.84	0, 1	7.50	327
1	2.92	1.89			
2	2.22	3.14			
3	1.22	2.29	2, 3, 4	2.75	227
4	0.77	1.07			
5	0.55	0.58			
6	0.17	0.56	5, 6, 7	1.50	618
7	0.41	1.11			
8	0.43	0.56			
9	0.13	0.27	8, 9	0.50	157
10	0.11	0.23			
11	0.11	0.13	10, 11	0.50	400
12	0.11	0.08			
(Anode)					

Specific activities of the starch gel extracts.—Enough material could be extracted from the starch gel to check the relative activity against two different substrates, sulfanilamide azocasein and sulfanilic acid azoalbumin. Two gels were prepared with pH 7.6 *Tris*-citrate buffer. Starch gel electrophoresis was carried out in the usual way. Following extraction and the determination of the protein distribution, those sections which apparently contained peaks of protein were combined. Table 4 lists the sections combined and the total activity per mg of protein of the combined extracts. In order to determine the activity of the extract the volume was first reduced by lyophilization. Then each extract was diluted with distilled water to a standard volume, five ml. One half ml of this was removed to test for enzyme activity. Another aliquot was removed to check the protein content. Then by accurately adjusting the volume of each combined extract, it was possible to

produce extracts having approximately the same amount of activity per unit of volume. Following this the activity of each extract was measured with the two substrates listed above. The results are given in table 5. A comparison in the form of a ratio of the activities with the two substrates, is presented in the last column. Presumably, if the separate extracts contained the same enzyme, the ratios would be identical. Since this was not found (table 5), this study indicated that the homogenate of the stable fly midgut contained a variety of different proteolytic enzymes of the trypsinlike type or least two (or more) enzymes in a variety of proportions.

DISCUSSION

Data in table 1 indicate that no differences exist in trypsinlike activity of midgut homogenates of either sex, providing that the homogenates are from the same group of flies. The term group refers to a population of flies reared from one aggregation of pupae which was subsequently handled in the same manner. Different groups of flies could not be compared in terms of activity per midgut or in terms of activity per unit of dry weight. Because of this, enough homogenate was prepared to supply the requirements for any experimental procedure prior to the actual experimentation.

TABLE 5

Specific activity of combined extracts

Extract Number	Sections Combined (Table 4)	Activity[1] Azocasein / Azoalbumin			Activity Ratio
(Cathode)					
1	0, 1	36.5	/ 8	=	4.6
2	2, 3, 4	48	/ 23	=	2.1
3	5, 6, 7	48	/ 14	=	3.4
4	8, 9, 10, 11	40.5	/ 16	=	4.6
(Anode)					

[1]Activity is an average of two determinations and is reported in terms of Klett units.

The activity characteristic was found by the formula method to be 15,600 calories. The formula substitution method of Neilands and Stumpf (1955) using the equation

$$k_2/k_1 = \frac{0.219\ \mu\ (T_2 - T_1)}{T_1 T_2}$$

was used.

K_1 and k_2 represent the activity at absolute temperatures T_1 and T_2. The temperature range selected was from 30 to 50°C. Lin and Richards (1956) have reported characteristics of 15,000 to 16,000 calories for the American cockroach using similar procedures. Hog trypsin was found to have a temperature characteristic of 15,600 calories with a casein substrate (Sizer, 1942).

Charney and Tomarelli (1947) report that vertebrate trypsin catalyzes the hydrolysis of azocasein and that this reaction follows the first order type. However, the curve in figure 1 demonstrates a zero order reaction since the substrate hydrolysis is directly related to time. Charney and Tomarelli used a higher substrate concentration, 20 mg per ml of reaction mixture, than was used in the stable fly midgut reaction mixture. Perhaps if the midgut concentration had

been increased or the substrate concentration decreased, a first order reaction might have resulted with the stable fly midgut protease.

The midgut homogenate was found to retain the same proteolytic activity in terms of protein nitrogen following dialysis against distilled water as it possessed prior to dialysis. This demonstrated that a dialyzable activator was not present. The addition of the cations, sodium, calcium, and magnesium, or the anions, chloride and fluoride, did not alter the rate of activity of the dialyzed homogenate.

Penicillin G was found to have no effect on the midgut trypsinlike activity. This indicated either that bacterial contamination was not present or it was unaffected by the antibiotic. Terramycin and dihydrostreptomycin were found to alter the substrate which in turn resulted in abnormally high activities with the midgut preparation. Nor was toluene a satisfactory substrate preservative since its use resulted in nonenzymatic cleavage and the hydrolyzed chromophoric group was soluble in the toluene layer. It was found best to keep the substrate solution frozen. This inhibited the hydrolysis of the azocasein.

Some confusion has been introduced into the literature by the statement of Champlain and Fisk (1956) that: "In the muscoid bloodsuckers, such as *Glossina* and *Stomoxys*, ingested food passes into the crop, where no digestion or denaturation occurs." It is now generally agreed that a more accurate appraisal is given in the well documented statement of Waterhouse (1957), namely: "Tabanids, *Phlebotomus*, and the stable fly *Stomoxys* also divert blood to the midgut and sugar solutions to the crop, whereas *Glossina* sends blood to both regions."

During laboratory feeding of stable flies with citrated bovine blood, blood entered the ventral diverticulum or crop in less than five percent of the flies. When these blood-filled diverticula were incubated with azocasein substrate at pH 7.8 no proteolytic activity was found. Nor was proteolytic activity detected in diverticula which showed an absence of ingested blood. Flies reared on sugar solutions were found to have enlarged clear fluid-filled diverticula indicating that the carbohydrate solutions had been taken into these structures. The midguts of these flies were smaller than in the blood-filled flies. Because of this, it seems likely that most of the carbohydrate material was taken into the diverticulum instead of the midgut.

At least three separate bands of trypsinlike activity were found following paper electrophoresis of the stable fly midgut homogenate. Paper electrophoresis was carried out with barbital buffer at pH 8.0. Since the amount of brei—20 microliters—was too small to elute from the paper, further characterization of this enzyme by this method was not attempted. Starch gel electrophoresis yielded enough enzymatic protein to test against two separate protein substrates, sulfanilamide azocasein and sulfanilic acid azoalbumin. In contrast to paper electrophoresis no cathodal migration of the enzymatic material was found after starch gel electrophoresis. This was true even though the buffer composition used in making up the starch gel and the pH of electrophoresis was the same as in paper electrophoresis. The reason for the difference in migratory behavior remains unknown. Perhaps it is associated with the nature of the electrophoretic substrate.

Another difference between the two methods was that the homogenate used with starch gel electrophoresis had been lyophilized and dialyzed while the homogenate used with paper electrophoresis had been untreated. However, the dialyzing and lyophilizing treatments have been shown to have no effect on total protease activity.

The distributions of the nonenzymatic protein and of the enzymatic material following starch gel electrophoresis was found to be independent of each other. This is illustrated in table 3 as the enzymatic content of the extracts did not vary proportionally to the nonenzymatic protein component of the serial extracts.

By comparing the activity per mg of protein of the original homogenate with

the activity per mg of protein in the various extracts, the degree of purification achieved following electrophoresis was determined. The highest degree of purification was found in the combined extracts of section four as listed in table 4. This amounted to a purification of 14-fold.

Some preliminary work was done on the possibility of using acetone and salt fractionation at different pH levels and temperatures to purify the enzyme. The highest purification obtained with a one-step acetone fractionation was about 14-fold. However, the total recovery of enzyme was only 28 percent. This purification was obtained in the supernatant of a homogenate buffer preparation which contained 20 midguts per three ml after it had been treated for four hours with an equal volume of acetone at 12° C. Then it was found that by shifting the pH to 9.0 (at the same temperature) the enzyme material could be precipitated with an additional two-fold purification. In this step there was an additional 72 percent loss in activity. Since this procedure required large amounts of homogenate, purification by this method was discontinued.

As previously mentioned, enough material was obtained in the starch gel extracts to study the comparative activities of the different extracts with the two available substrates. If the volumes of the extracts could be adjusted to the same enzymatic activity per unit of volume, using one substrate as a standard, then each extract should have the same relative activity when tested against a second substrate if the same enzyme was present in each. If the extracts contained qualitatively different proteolytic enzymes, then the activities of the extracts in the second substrate would be expected to vary. However, it was found diffcult to adjust the volumes of the extracts accurately so that the different extracts would have the same activity per unit of volume with one substrate. Instead, the volumes of each were adjusted so that they had as nearly as possible the same concentration of the enzyme. A pipette graduated in hundredths of a milliliter was used to adjust the volumes of the extracts following the first activity determination.

Then, in duplicate experiments, the same volume of each extract was added to each of two test tubes. The same clean dry 0.5 ml pipette was used for each transfer. After equilibration in the 40° C water bath, a two ml aliquot of one substrate was added to one of the tubes representing each extract. The second substrate was added to the other test tube. Appropriate water blanks were tested simultaneously. This entire procedure was repeated and the results averaged.

At the end of the incubation period the reaction was stopped and the activity of each extract with the two substrates was compared. This was done in the form of a ratio as listed in table 5. The ratio for each extract should be the same if the enzyme contained in the extracts was of the same type. But the activity ratio was found to vary for the different extracts. This is a good indication that some qualitative difference existed in the proteolytic enzyme of the extracts.

This evidence, combined with the appearance of three activity peaks found in paper electrophoresis, leads to the conclusion that the midgut trypsinlike enzyme of the stable fly is a complex of trypsinlike enzymes. Perhaps this has some bearing on the different enzymatic activities of homogenates prepared from different groups of flies. That is, variation in the physiological condition of the flies and of the bovine blood might affect the constitution of the trypsinlike enzymes secreted into the gut.

SUMMARY

In a study of the midgut trypsinlike enzymes of the stable fly, *Stomoxys calcitrans* (L.), no trypsinlike activity was found in the diverticulum. The diverticulum was found to contain blood in less than five percent of the flies following laboratory feeding of citrated bovine blood. Also no difference was

noted in the trypsinlike activities of midgut homogenates prepared from male and female flies taken from the same population of flies.

Differences were found in homogenates prepared from different groups of flies. The trypsinlike proteolytic action was found to follow the zero order type of reaction at the concentrations of substrate and homogenate used. No evidence of a dialyzable activator was found. The addition of certain metallic ions—magnesium, sodium, and calcium—and the anions—chloride and fluoride –to dialzyed homogenates did not affect the reaction.

Paper electrophoresis of the homogenate indicated that the midgut contained at least three trypsinlike substances which possessed different electromobilities. Two of these bands moved toward the cathode while the third remained stationary at pH 8.0 using barbital buffer of ionic strength 0.05. An attempt was made to increase the yield by electrophoresis of larger quantities of homogenate by the use of starch gel electrophoresis. However, no cathodal movement of the enzyme was found in the starch gel. Serial extractions of the starch gels demonstrated different peaks of activity on the anodal side of the starting point. A comparison of the activity of several of the peaks with different substrates demonstrated the likelihood that the peaks represented different trypsinlike components of the stable fly midgut protease.

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FOOD, GROWTH AND SEXUAL DIMORPHISM OF THE REDSIDE DACE *CLINOSTOMUS ELONGATUS* (KIRTLAND) IN LINESVILLE CREEK, CRAWFORD COUNTY, PENNSYLVANIA[1]

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Kirtland described in 1836 an attractive and widely distributed cyprinid, the redside dace, *Clinostomus elongatus*. It is surprising that since that time researchers have given little or no attention to this species. Koster (1939) published a brief work on its life history and Evans and Deubler (1955) studied tooth replacement. Greeley (1927, 1936), on the basis of one or two specimens, comments that this species feeds on insects and will rise to an artificial fly. Breder (1920a, 1920b) and Deubler's unpublished thesis (1955) remain the only other works involving a member of this genus, *Clinostomus vandoisulus*.

As a result of this paucity of literature, it was decided to investigate further the life history of the redside dace. This study includes: 1) a general food study of specimens taken from the same creek; 2) a comparison of food consumed by the young and adults; 3) the role of age in food preference; 4) supplementary information on sexual dimorphism and growth rates.

MATERIAL AND METHODS

Two hundred and thirty-four specimens of the redside dace were collected in seven samples during 1955. At least 10 specimens were taken each month except when collecting was made impossible by ice, high waters, or inclement winter weather.

The method of food study consisted of examining the stomach contents of each fish and estimating visually the percent volume of each group of food present. Samples which contained material that could not be identified were mounted on glass slides for later study.

Measurements taken of the standard length, head length and pectoral length followed the methods of Hubbs and Lagler (1947). The age was determined by removing scales from the area just below the dorsal fin and dorsad to the lateral line. Less difficulty was found with redside scales than was experienced by Breder (1920a) with *C. vandoisulus* scales. Individual fish were weighed on a triple beam balance, accurate to 0.01 gm. Sex determinations consisted of noting the size and shape of the anal papilla, length of the pectoral and pelvic fins, and body coloration, verifying the determination by an internal examination of the gonads.

HABITAT

Linesville Creek is a small, gravel, mud and sand-bottom creek located at Linesville, Crawford County, Pennsylvania, approximately 10 mi east of the Ohio-Pennsylvania border. This stream flows through fields and pastures and drains into Pymatuning Lake whose outlet flows into the Shenango River, Ohio drainage. The stream varies in depth from one to three ft and has an average width of 30 ft. The redside dace in Linesville Creek is found in pools with a

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gravel-sand bottom having a depth of two ft. It is known to spawn in this type of habitat (Koster, 1939).

FOOD

In their natural habitat, as well as in aquaria, the redside dace readily jump several inches into the air to catch a hovering insect. This jumping, coupled with a large mouth and the vigorous swimming activities of this species, suggested that this fish was a mid-water or surface feeder.

TABLE 1

Food of Clinostomus elongatus *(Kirtland), by months, expressed as percentage frequency of occurrence and volume*

Month	March		April		May		June		July		August		October		Total	
Percentage frequency (F) and Volume (V)	(F)	(V)	(F)	(V)	(F)	(V)	(F)	(V)	(F)	(V)	(F)	(V)	(F)	(V)	(F)	(V)
Insects																
Ephemeroptera	17.4	14.0	5.5	2.0	5.6	3.0	6.0	5.5							7 6	3 9
Odonata									40.0	12.0					5.0	1.7
Plecoptera			3 0	0.8											1 0	.1
Thysanoptera									7.0	1.0					1 0	.1
Hemiptera																
Heteroptera							3.0	5.0					8.0	1.0	18.7	.9
Homoptera	12.6	7.0	8 3	2.0	14.6	6.0	15.1	9.0	40.0	5 0	8.7	7.0	8.0	3.0	16.7	5.6
Neuroptera					1.1	1.3									1.0	1.1
Hymenoptera																
Ichneumonidae					2 0	0.3					4.3	13.0			18 8	1 9
Formicidae	4.3	2.0	8.3	2.0	9.8	4 0	3.0	6 0	14.0	11.0	8.7	13.0	31.0	23.0	10.0	8 8
Other					1.1	0.1	12 0	1.0	20.0	25.0	8.7	10.0	31.0	23.0	8.5	7 1
Coleoptera																
Curculionidae					9.0	16.0									17.3	2.3
Other	12.6	4.0	14.0	2.0			9.0	6.0	27.0	28.0	8.7	11.0	46.0	23.0	11 9	10.6
Lepidoptera					3.0	2.0									1.5	.3
Diptera																
Pupae	4.3	19.0	88.8	59.4	4.5	0.6									18.8	11.2
Adults																
Empididae					16.9	9.0									7.6	1.3
Other	35.0	8.0	41.4	21.4	5.6	23.0	33.0	26.5	30.0	9.0	13.0	14.0	23.0	5.0	24.5	15.2
[illegible]					1.1	.04	3.0	1 0			4 3	1 0			1.5	.3
Umdentifiable remains	65.2	42.0	22.2	10.0	67.4	34.0	33.0	18.0	20.0	9.0	17.0	30.0	54.0	15.0	55.0	22.6
Material other than insects																
Arachnida	4.3	3.0					12.0	16.0					31.0	3.0	4 6	3 1
Hydracarina			14.0	0.2	18.0	0 3									10.5	.1
Nematoda			11.1	0.2	7.8	0 1									6.0	.04
Plants					4.5	0.3	9 0	6 0							4 0	.9
Debris (Inorganic)	4.3	1.0													1 0	01
Total																99.15
Total Specimens Male/ Female	8/17		15/21		13/76		11/22		1/14		2/21		0/13		234	
Total Stomachs Full	0/1		2/4		1/9		2/2		0/0		0/2		0/3		25	
[illegible]	0/1		2/1		0/7		5/7		1/6		1/7		0/9		38	
Total Stomachs Partly Full	8/15		11/16		12/60		4/13		0/8		1/12		0/11		171	

The food data, summarized by months in table 1, substantiated this conclusion. Insects comprised 95.00 percent of the total food, by volume. Terrestrial insects made up 76.9 percent of the total. Seventeen percent of the total volume consisted of bottom forms such as diptera pupae (11.2), Ephemeroptera (3.9) and Odonata (1.7) with traces of other bottom insects. The remaining five percent

of the total food eaten was composed largely of Arachnids (3.0), while Hydracarina, Nematoda, plants and debris contributed a little more than one percent to the redside diet. Plankton was not found in any of the stomachs; however, one stomach was found containing a quantity of debris which consisted of mud and wood particles.

Diptera pupae and adults, comprising 27.7 percent by volume and 50.9 percent by frequency, were the most common insects found in redside stomachs. Other orders of insects found in the stomachs occurred in approximately the following sequence by percent volume: Hymenoptera (17.8), Coleoptera (12.9), Hemiptera

TABLE 2

Food of Clinostomus elongatus *(Kirtland), by age class, expressed as percentage of frequency of occurrence and volume*

Percentage Frequency and Volume	1 yr. (F)	1 yr. (V)	2 yr. (F)	2 yr. (V)	3 yr. (F)	3 yr. (V)	4 yr. (F)	4 yr. (V)	Total (F)	Total (V)
Insects										
Ephemeroptera	6.7	3.2	5.3	2.2	12.6	7.2	40.0	20.0	7.6	3.9
Odonata					4.6	3.8			5.0	1.7
Plecoptera			1.7	0.4					1.0	.1
Thysanoptera			1.7	0.2					1.0	.1
Hemiptera										
Heteroptera					9.0	4.0			18.7	.9
Homoptera	11.2	5.4	17.3	7.8	9.0	5.0	40.0	7.5	16.7	5.6
Neuroptera			1.7	1.3					1.0	1.1
Hymenoptera										
Ichneumonidae	1.0	0.9	7.0	2.5					18.8	1.9
Formicidae	6.7	2.2	19.4	10.5			20.0	6.7	10.0	8.8
Other	2.4	3.0	7.0	6.7	9.0	3.2	40.0	14.0	8.5	7.1
Coleoptera										
Curculionidae	6.0	0.4	3.5	1.0	18.1	4.5	20.0	4.0	17.3	2.3
Other	10.1	8.9	26.3	14.1	18.0	9.2			11.9	10.6
Lepidoptera	2.5	1.3	1.7	.3					1.5	.3
Diptera										
Pupae	18.6	14.9	19.3	9.6	9.0	6.6	20.0	8.0	18.8	11.2
Adults										
Empididae	10.1	4.8	1.7	.01	12.6	1.1			7.6	1.3
Other	39.0	22.6	42.1	16.5	18.1	7.4	40.0	18.0	24.5	15.2
Eggs (Insect)?			1.7	0.4	4.6	0.8			1.5	.3
Unidentifiable remains	62.5	30.0	36.8	21.7	60.0	39.0	40.0	19.0	55.0	22.6
Material other than insects										
Arachnida	9.0	1.5	3.5	3.0	9.0	3.6			4.6	3.1
Hydracarina	11.0	0.2	3.5	0.1	9.0	0.1	20.0	0.3	10.5	.1
Nematoda	6.7	.09	3.5	0.1	4.6	0.2			6.0	.04
Plants			3.5	0.5	4.6	4.3	20.0	2.5	4.0	.9
Debris	0.9	.01							1.0	.01
Total										99.15

(6.5), Ephemeroptera (3.9), Odonata (1.7), Neuroptera (1.1), while Lepidoptera, Plecoptera and Thysanoptera all appeared less than one percent of the time. By frequency of occurrence the same order existed as for volume (table 1). Eggs (insects ?) formed 0.3 percent of the food. These eggs were always found in close proximity with insect abdomens and were, therefore, considered to be of that insect's origin. Unfortunately, unidentifiable insect remains, fragments of legs, eyes, thorax or unknown immature insect stages, made up a large percentage (22.6) of the total insect food.

There was a seasonal difference in the quality and quantity of food consumed (table 1). Diptera pupae (19%) and Ephemeroptera nymphs (14%) were eaten in the greatest quantity in March, compared to a yearly average of 11.2 and 3.9 percent, respectively. In subsequent months, stomach contents showed a gradual increase in food size and quantity, from larval and small adults to primarily large adult insects. The fishes' preference for Diptera, which composed 32.6 percent of the food volume for May, decreased throughout the summer and fall months as more of the larger Coleoptera and Hymenoptera were eaten. A peculiar point to note here was the presence of Ephemeroptera during the period from April through June in the stomach contents of the redside dace. This leads one to suspect this group of being a secondary source of food, during the period from October to March when winged forms are absent.

It was apparent that the size of food was an important factor in its utilization (table 2). There was a general increase in the size of food organisms consumed as the size of the fish increased. This difference was noted by Forbes (1878, 1880) and Breder and Crawford (1922) for other cyprinids. Year-group 1 (terminology follows Rounsefell and Everhart, 1953) fed mostly on small Diptera (42.3% by volume, table 2) and a few Coleoptera and Hemiptera (*Aphrophora carotogensis* and *Philaenus leucophthalmus*). Specimens of year-group 2 consumed Coleoptera (9.3–15.1%) and Hymenoptera (6.1–19.7%) in preference to Diptera 42.3–26.1%). Specimens in year-group 3 were noted to also prefer, by volume, adult Coleoptera (13.7%) and Hemiptera (9.0%) to Diptera (8.5%). Although year-group 4 fish were noted to have eaten large quantities of Ephemeroptera (20%), Diptera (26.0%) and Hymenoptera (20.7%), the small number of fish and the season of their capture (March, May, and October) lessened the true importance of these forms as food for this year-group.

SCALE FORMATION AND DESCRIPTION

Clinostomus scale annuli are laid down before October 25 since specimens taken after October 25 show occasional additional circulae development. However, circulae production can be evident on specimens taken as early as March 4.

Annuli can best be distinguished in the scale's anterior field as a clear zone between two circulae. This annulus can be traced within the anterior field of the scale and is not delineated (Lagler, 1950) by cutting-over but by a running-together of circulae adjacent to the annulus zone laterally. This produces one prominent circulus which then traverses the posterior field, bifurcating around the annulus on the other side. Circulae of the posterior field, since they are evenly and widely spaced, should not be used as the only criteria for locating the annulus.

GROWTH AND SEXUAL DIMORPHISM

On plotting the growth at each age for each sex, it was decided to lump all the specimens throughout the collecting period into apparent age groups. This was imperative since males virtually disappeared after June, yielding samples composed mainly of females of all ages (table 1). Males collected during this same period, June to October, were three years old.

Although both the standard and head lengths (table 3) tend to fluctuate widely between year-groups 1 and 3, there is a general decrease in growth increment of 50 percent annually. Apparently a change in the growth rates of both sexes occurs somewhere between 35 and 50 mm standard length. Female dace (table 3) weights were noticeably heavier for all ages except year-group 2 where males slightly exceeded females in weight.

Pectoral fin lengths, however, for all specimens are always longer for males than for females. In a comparison of the ratios of head length and pectoral fin length to the standard length and to each other by age and sex, it is evident that the pectoral fin length in head length ratio is the best and least variable criteria by which one can readily sex redside dace throughout the year (table 4). A

1.15 to 1.19 (male) and 1.36 to 1.41 (female) pectoral in head length ratio exists for year groups 2 to 4. The same comparative ratios for year class 1 are 1.38 for males and 1.44 for females, respectively. The pectoral length in standard length ratio can be used secondarily to distinguish between sexes beyond year-group 1; however, the range of variation is often enormous. For this reason this criterium should be used cautiously. Genital papillae, although tubular and/or rigid ventrally and of varying lengths within sexes, should be used sparingly as a sex recognition character at other than the breeding season.

TABLE 3

A comparison between mean standard, head and pectoral fin lengths and weights for various age groups of Clinostomus elongatus *(Kirtland) from Linesville Creek, Crawford County, Pennsylvania*

	Year Groups							
	1		2		3		4	
	Male	Female	Male	Female	Male	Female	Male	Female
Number of specimens	25	93	12	66	12	19	2	4
Standard Length—Mean	39.08	39.70	57.35	54.79	66.43	68.54	74.50	74.56
Standard Deviation	3.59	5.50	4.52	5.17	2.86	2.23	3.90	4.41
Head Length—Mean	10.56	10.45	15.20	14.40	17.10	17.98	18.53	19.63
Standard Deviation	1.33	1.79	1.68	1.84	1.37	1.39	.5	.5
Pectoral Length—Mean	7.68	7.25	12.94	10.60	14.41	12.84	16.16	13.96
Standard Deviation	1.19	1.25	1.64	1.49	.69	1.08	.77	.45
Weights	1.05	1.20	3.09	2.91	4.76	5.81	5.70	7.28

TABLE 4

A comparison of ratios of body proportions of Clinostomus elongatus *(Kirtland)*

	Year Group							
	1		2		3		4	
	Male	Female	Male	Female	Male	Female	Male	Female
Head Length in Standard length	3.70	3.80	3.77	3.80	3.88	3.81	4.02	3.80
Pectoral Length in Standard Length	5.09	5.48	4.43	5.16	4.61	5.34	4.61	5.34
Pectoral Length in Head Length	1.38	1.44	1.17	1.36	1.19	1.40	1.15	1.40

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SUMMARY

Two hundred and thirty-four specimens of *Clinostomus elongatus* from Linesville Creek, Crawford County, Pennsylvania, were sampled for studies of food, growth and sexual dimorphism during 1955.

The food of the redside dace consisted of 76.9 percent terrestrial insects. Seventeen percent of the total volume was composed of bottom forms such as Diptera pupae, Ephemeroptera and Odonata. Only a little over four percent of the food consisted of groups other than insects such as arachnids, hydracarina and plants.

Diptera formed the greatest quantity, 27.7 percent volume, and the most frequent food item in the diet. Other orders, such as Coleoptera and Hymenoptera contributed the next greatest quantities as food items.

A shift in the size and quantity of food was noted from that of Diptera to Coleoptera and Hymenoptera during different months of the year and by age groups. Older fish tend to feed on larger organisms than fish one year old.

Much variation exists in the standard and head lengths of redside dace; however, a general growth-increment decrease of 50 percent annually was noted.

Annuli are laid down by October 25 while circuli formation is evident as early as March 4.

The annulus is a clear zone best seen in the anterior field of the scale and delineated on the sides by successive circulae running together to form one prominent circulae within the posterior field.

Pectoral fin lengths can be used with certainty at all times of the year as a means of distinguishing between sexes. Male fins for all specimens and year groups are longer than female fins. A general relationship of 1.15 to 1.19 (males) and 1.36 to 1.41 (females) exists for the pectoral in head length ratio of fish 2 to 4 years old.

The pectoral fin in standard length ratio may be used cautiously as a recording means of distinguishing between sexes.

The use of genital papilla shape and length should be used sparingly as only during the breeding season are they distinct Throughout the remainder of the year their shapes may be rigid or tubular in either sex.

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A PRELIMINARY INVESTIGATION OF THE SOCIAL PSYCHOLOGY OF ATTITUDES TOWARD MEDICAL DOCTORS*

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INTRODUCTION

Favorable attitudes on the part of patients toward their doctors are widely recognized as an important element in modern psychotherapy Yet, despite observations by anthropologists that in preliterate societies popular belief in the shaman's power is an integral part of the cure, in the field of physical therapy little formal attention has been given this problem. In another study the author found that attitudes toward the medical profession held by patients released from tuberculosis hospitals were related to the tendency to complete hospitalization.† This paper presents some of the relationships found between the attitudes of these same patients toward doctors and certain other variables.

In this study attitudes are viewed not as independent "causes" but as intervening variables between individual motives and behavior. The criterion variables—attitudes toward medical doctors—are considered just such representations. Favorable attitudes toward doctors do not cause the individual to remain in the hospital until the doctor says he may leave. Favorable attitudes do, however, belong along with other attitudes to a kind of configuration, all of which together integrate the perceptions which an individual has of the hospital situation. Also, these very attitudes serve the function of selecting out certain aspects of the hospital environment for the patient to experience. And finally, attitudes toward doctors, in combination with other attitudes, probably serve to stimulate individuals to act in certain ways.

Although sociologists know little enough of the etiology of attitudes, we assume they are acquired by the self as it interacts with or experiences its social environment. Just as attitudes serve the functions of selecting, integrating, and stimulating behavior, so social interaction must offer the structural counterparts of these activities to the individual. One most effective selector in social experience is, as research studies have shown, the position which the individual holds in the social structure, or social status. In social experience, values act as integrators. The social stamping of doctors, for instance, as "good" or "bad" by other members of the child's family helps him to coordinate the various and sometimes conflicting perceptions he receives of the doctor. The stimulators are mainly found in the actions of other persons which force the person to react. When the patient enters the doctor's office and the latter looks up with a kindly smile and addresses him, the patient is compelled to action—probably to return the smile and be pleasant to the doctor. This behavior contributes to his conceptions of both the doctor and himself.

METHODS

On the basis of the rationale just described, certain hypotheses were established

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†Unpublished Ph.D. dissertation: *Predicting Stay or Leave Response of Hospitalized Tuberculosis Patients*, Department of Sociology and Anthropology, The Ohio State University, 1954.

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and related items were selected from a questionnaire* which had been administered to former patients at an urban county tuberculosis hospital. Criterion groups of favorable and unfavorable patients were established by devising a Doctor Attitude Scale from statements (also from the questionnaire) designed to measure attitudes toward doctors. The scale was validated and finally the significance of the differences between the responses of the criterions groups to the selected items was determined by means of the Chi Square test.

Attitudes toward doctors were hypothesized as being related to the following: *1.* Attitudes toward other specific specialists and toward experts in general. *2.* Attitudes toward selected dimensions of the role of doctors in our society. *3.* The social statuses occupied by any given individual in this society. *4.* The evaluation of medical doctors made by the individual's family and the actions of doctors as perceived by the patient.

TABLE 1

Attitudes toward certain other experts, held by respondents classed as favorable and unfavorable toward medical doctors

Items	Attitudes Toward Medical			
	Favorable		Unfavorable	
	No.	Percent	No.	Percent
1. Greater self-knowledge than psychiatrist:				
Agree	11	28.2	25	41.7
Disagree	28	71.8	35	58.3
Total	39	100.0	60	100.0
2. More confidence in mothers than in teachers:				
Agree	17	48.6	39	66.1
Disagree	18	51.4	20	33.9
Total	35	100.0	59	100.0
3. Nurses act as though sick are inferior:				
Agree	1	2.7	22	36.7
Disagree	36	97.3	38	63.3
Total	37	100.0	60	100.0
4. People being pushed around by experts:				
Agree	16	40.0	43	72.9
Disagree	24	60.0	16	27.1
Total	40	100.0	59	100.0

The following six statements were incorporated in a crude scale, each item being arbitrarily assigned two weights. To make a score optimum to favorable toward doctors, a respondent would have to disagree with these items: *1.* Doctors tend to act superior to their patients. *2.* Doctors today seem to be more interested in money than in their patients. *3.* It is difficult to find a doctor you can really trust. *4.* Too many doctors treat their patients as if they were not capable of understanding anything. And the subject would have to agree with these: *5.* Doctors ought to be respected by everyone. *6.* Doctors cannot be expected

*The questionnaire was used in gathering data for the unpublished Ph.D. dissertation: *Predicting Stay or Leave Response of Hospitalized Tuberculosis Patients.*

to tell their patients much since they have so much technical knowledge that only another doctor could understand.

Patients who failed to respond to more than three items were discarded from the sample. On the average, four of these six items were responded to favorably. Patients with scores falling in the classes below the mean were assigned to the "Unfavorable" category, and those in the classes above, to the "Favorable," the mean class having been excluded from the analysis.

Talcott Parsons (1951) has characterized the ideal patient-doctor relationship as one in which the physician tries to help and the patient cooperates. To determine the validity of the scale, that is, whether the six items really discriminate between those who hold favorable and unfavorable attitudes, the two groups were examined in terms of their cooperation with doctors at the tuberculosis hospital. One measure of cooperation was whether the patient left the hospital with or against medical advice. Thirty-five of the forty-one Favorable patients left with medical advice; on the other hand, forty of the sixty-two who were Unfavorable left against the advice of their doctors. Differences between these distributions are significant at the one percent level of confidence.

TABLE 2

Attitudes toward one aspect of the doctor's role—(impersonal authority), held by respondents classed as favorable or unfavorable toward medical doctors

Items	Attidues Toward Medical			
	Favorable		Unfavorable	
	No.	Percent	No.	Percent
1. Beneficiaries of rules are those who enjoy enforcing them:				
Agree	7	17.9	24	40.7
Disagree	32	82.1	35	59.3
Total	39	100.0	59	100.0
2. Most red tape is unnecessary:				
Agree	15	42.9	44	74.6
Disagree	20	57.1	15	25.4
Total	35	100.0	59	100.0

RESULTS AND DISCUSSION

Three items in the questionnaire seemed to be indicators of opinions about specific experts; one item, about experts in general. They are: *1.* I know more about myself than anybody else can ever know about me, including a psychologist or psychiatrist. *2.* Young, unmarried women with college degrees teaching in our public schools know less about handling children than the mothers who have learned from experience with their own children. *3.* Nurses act like sick people are inferior to other people. *4.* An awful lot of people are being pushed around by so-called experts.

Distributions on these items appear in table 1. Differences between the two groups are statistically significant for only the last two items. In this sample, differences between patients favorable and unfavorable toward doctors were not observed on the questions involving acknowledgment of skills of specific experts, there being general agreement about the superior knowledge of a psychiatrist or psychologist compared with laymen, and the questionable abilities of college trained teachers compared with mothers. On the other hand, unfavorableness toward doctors appears to be related to opinions about the manner in which

certain experts act toward other persons. On the face of it, agreement with the statements about the condescending behavior of nurses and the manipulating acts of experts involves threats to the security of the individual, whether to that of ego or someone else. There appears to be some relationship between answers to the two questions since all fifteen respondents who agreed with both questions were in the Unfavorable group. Of the twenty-four Favorable patients who disagreed with the statement about experts, twenty also disagreed with the nurse statement. Before leaving the discussion of these items, it should be mentioned for the benefit of readers who recognize the question on so-called experts as deriving from the F-test (Adorno et al., 1950) that for this study the item was accepted at face value. The interpretation, therefore, does not hinge upon "depth psychology" theories.

TABLE 3

Some differences in selected social statuses of respondents classed as favorable or unfavorable toward medical doctors

Items		Attitudes Toward Medical			
		Favorable		Unfavorable	
		No.	Percent	No.	Percent
1. Race:	White	26	63.4	51	82.3
	Other	15	36.6	11	17.7
	Total	41	100.0	62	100.0
2. Occupational prestige:	73–93	5	13.2	5	8.8
	63–72	9	23.7	18	31.6
	53–62	10	26.3	28	49.1
	33–52	14	36.8	6	10.5
	Total	38	100.0	57	100.0
3. Sex:	Male	24	58.5	29	46.8
	Female	17	41.5	33	53.2
	Total	41	100.0	62	100.0
4. Age:	50 years and over	9	22.0	8	12.9
	35–49	10	24.4	9	14.5
	25–34	17	41.4	28	45.2
	under 24	5	12.2	17	27.4
	Total	41	100.0	62	100.0
5. Education:	Beyond high school	5	12.2	9	14.5
	High school	20	48.8	34	54.8
	Eight or less grades	16	39.0	19	30.7
	Total	41	100.0	62	100.0

Two items in the questionnaire were classified as being indicators of one important dimension of the doctor's role in our society—impersonal authority.

1. The people who benefit most from rules and regulations are the ones who get satisfaction from laying them down to others.

2. On the whole, most of the red tape you come across today is really not necessary.

The manner in which the two groups responded to these statements may be observed in table 2. The probability of differences as large as are found in the responses of the two groups to the first item is less than two out of one hundred; for the distribution on the second item, less than one out of one hundred.

The common element in the two items—"red tape" in the one and "rules and

regulations" in the other—provides the clue to an understanding of impersonal authority. It is clearly demonstrated in the "red tape" situation where someone either explicitly or implicitly imposes "rules and regulations" on some important area of an individual's life (Parsons, 1951, p. 434). In the last analysis, decisions are made not on the basis of the individual's immediate relationship to this person, but in terms of general rules or laws covering such cases as his (Merton, 1949, p. 158). Facing this type of authority, the individual may be forced into recognizing his own inability to alter his position in the power relationship. Consequently, the confrontation of impersonal authority leaves certain individuals with a sense of powerlessness (Gouldner, 1952, p. 410).

Distributions of the two groups by selected social statuses are shown in table 3. There is a significantly greater (at the five percent level) number of minority group members in the Favorable group. There is also a significantly greater proportion of very low prestige occupations (National Opinion Research Center, 1947, pp. 411–426) and a lower proportion of next-to-the-highest prestige occupations in the Favorable group. Three status factors did not appear to be related to attitudes toward doctors—sex, age and education.

TABLE 4

Effects of evaluation and actions of medical practitioners on respondents classed as favorable or unfavorable toward medical doctors

Items	Attitudes Toward Medical			
	Favorable		Unfavorable	
	No.	Percent	No.	Percent
1. Family practice of calling in or going to doctors:				
Yearly check and went immediately	24	64.9	36	65.5
Delayed and never went	13	35.1	19	34.5
Total	37	100.0	55	100.0
2. Change in attitude toward doctors since hospitalization:				
Change	11	27.5	30	49.2
No change	29	72.5	31	50.8
Total	40	100.0	61	100.0

The associations between both lower occupational status and minority group status and the criterion are discussed jointly because of the well-documented relationships between the two status factors. One explanation for the findings may lie in the fact that such individuals, who as a result of their status are in so many ways vulnerable to exploitation, have recourse to few alternatives other than faith in authority. Applicable are the studies which show that Negro and lower class elements are attracted to such religious movements as Father Divine, the Holy Rollers, etc. (Fauset, 1944; Powdermaker, 1939). Higher status individuals, while they do not have all the technical information bearing on their particular case, can exercise a greater degree of rational behavior in the total situation than can lower class persons. Furthermore, the data are suggestive that individuals with higher socio-economic status, being accustomed to more degrees of freedom, express more criticism of those who are in a position to restrict it.

One question was believed to determine indirectly the evaluation of medical doctors made by the patient's family of orientation. Patients were asked, "How did your family (in which you grew up) feel about calling in or going to doctors?" Differences between the answers of the two groups are not greater than one might expect from chance (table 4).

Since for many patients their most recent contact with doctors was that at the hospital, the question following the check list of items about doctors was believed to be pertinent for determining the effects while the actions of doctors have on patients. "Do you think your opinions about doctors are different since you have been in the TB hospital?" Whereas almost two-thirds of the Favorable group answered that they had not experienced any change of attitudes toward doctors as a result of hospitalization (table 4), about half of the Unfavorable group reported that their attitudes had been changed. Differences are significant at the five percent level.

It is to be noted then, that whereas the evaluation of doctors made by the individual's family does not appear related to attitudes toward doctors, the person's reactions to doctors at the hospital do appear to enter in.

CONCLUSIONS

This study offers a contingency technique to study what medical people might call the epidemiology of favorable-unfavorable attitudes toward physicians, being limited to a special category of subjects. The limitations of this technique in establishing causal relationships are recognized as well as the weakness deriving from the fact that the study was not designed with the above analysis in mind. For these reasons the findings are presented as suggestive of the need for further investigation.

With regard to the hypotheses set forth in the early part of the paper, the results of the item analysis in the last section indicate that more specificity in the hypotheses is merited in order to test them conclusively. On the basis of the evidence presented in this paper, the hypotheses might be restated as follows:

1. Unfavorable attitudes toward doctors are related to unfavorable attitudes toward the manipulative and condescending aspects of the behavior of other specialists with regard to the respondents themselves and others.
2. Unfavorable attitudes toward medical doctors are related to unfavorable attitudes toward impersonal authority.
3. Unfavorable attitudes are related to higher than average occupational status and to majority group status (racially).
4. Unfavorable attitudes are related to the way in which medical doctors act toward patients in their professional relationships with them.

If further data should permit the researcher to reject the null hypotheses, a generalization based on possible inter-relationships between the four hypotheses might be made. We might speculate that unfavorable attitudes toward medical doctors are part of an attitude-behavior pattern which derives from the status-role configuration which centers around specialists of various kinds and the recipients of their services. That is, persons in the more prestigeful statuses in our society (such as White and occupationally higher) are expected to resent impersonal authority and to feel distrustful of the power of persons institutionally provided with it, such as specialists of various kinds whose training and skills may or may not be acknowledged. Such status-connected attitudes are reinforced to a considerable degree by the experiences which the status-occupants have with the specialists.

The actual results of this study and the discussion of the usefulness of testing more specific hypotheses appear to point up questions in three major areas, as follows:

1. What is the etiological significance of attitudes toward physicians? In this connection, the interaction aspects of the patient-doctor relationship require considerably more investigation. One notable study of the observation of patient-doctor interaction on a ward is by Caudill (1952). We have indicated that some doctors may act or fail to act in such a way as to deserve the unfavorable opinion of their patients; the techniques of the Caudill study might be oriented toward the

problem of what it is that actually happens in the hospital to change the patient's good opinion of doctors.

2. Closely related and more important methodologically, what assurance do we have that the criterion variables selected for these studies, such as Favorable-Unfavorable, one side of which represents certain approved values having a high rating in our cultural context, are not blinding us to our own findings? Even our hypotheses may reflect conscious or unconscious favoratism, as specialists ourselves, toward the "Favorable" respondents.

3. What general trends in social structure are indicated by hostility toward and suspicion of experts in a society in which there is a growing dependency upon such persons? Research in this area could lead to important findings regarding value orientations in American society (Williams, 1951). Perhaps acceptance of technologically and professionally trained elites necessarily conflicts with democratic ideologies, which are more rigorously held by certain segments of our population than others.

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